THE

ELECTRICAL REVIEW.

VOL. XXXVI. MARCH 15, 1895. No. 903.

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SUBSCRIPTION RATES.—In *Great Britain*, Post Free, per Year, 19s. 6d. To all *other Countries*. per Year, £1 4s.

BINDING.—Subscribers' numbers bound, including case, for 4s. each volume.

CASES.—Cloth Cases for Binding can be had, price 2s. 6d. each.

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THE ELECTROLYSIS OF PIPES BY ESCAPING ELECTRIC RAILWAY CURRENTS.

IN view of the rapid extension of the direct system of electric traction in which the return current passes wholly or partly through the earth, it is of the greatest importance to investigate the corrosive action of this current on gas and water pipes, and the means to be adopted for counteracting this effect. A valuable report of an investigation on this question, made by Mr. John A. Barrett in Brooklyn, appeared in our contemporary, the *Street Railway Gazette*, a short time ago. An extensive series of tests of the electrical condition of the hydrants on the public water-pipes was made along the trolley roads. Differences of potential were measured between the hydrant and rail, between the hydrant and at least three earth points, and between the same earth points and the rails; and in some instances between the hydrant and gas pipes and between hydrant and elevated railroad. These measurements indicated whether the tendency of the current was to pass to or from the water-pipes in the neighbourhood of the hydrant.

In the ordinary voltaic cell the current flows from the zinc, which is corroded, passes through the electrolyte, and flows into the copper which is not corroded. The action of the return current of electric railways is exactly analogous to this. A current of electricity entering the pipes from the earth has no injurious corrosive action; it is where the current passes from the surface of a pipe into earth, or into a wet or watery conducting medium, that the corrosion of a pipe is actively stimulated.

In Brooklyn the single trolley system is in use, the positive pole of the generators being connected to the outgoing trolley wire. The current descending from the overhead wire through the cars of the system to the rails seeks to return to the power station, and in its return distributes itself over several different paths, according to the facilities offered. The greater portion of the current returns harmlessly by the rails, or by any supplementary special feeders which may be provided; but it is found that even with the most expensive system of return conductors, the rails at points very distant from the supply stations are at a higher potential than the earth and water pipes. The part of the return current which passes through the earth naturally takes advantage of the superior conductivity of the gas and water pipes situated in the neighbourhood, so that, as a general rule, electricity is flowing to the pipes from the rails in the more remote parts of the city, and is flowing from the pipes to the rails or other short circuits in the neighbourhood of the power stations. The points of exit, however, are not always distributed according to the simple rule indicated above; disturbing causes, such as the proximity

of another electric railway, may produce an irregular distribution. They can always be mapped out, however, for a given district by measuring the difference of potential between the pipes and the rails at a sufficient number of places. Mr. Barrett examined some of the mains in dangerous localities, but was unable to discover in the few points uncovered any distinct evidence of excessive corrosion. He was informed, however, that service pipes in these neighbourhoods had been frequently destroyed. He concluded that the corrosive action tends to concentrate itself on certain places where the conditions are specially favourable.

The remedies proposed by Mr. Barrett are, in the first place, the construction of as perfect a system of return conductors as can be made at reasonable cost, and, in the second place, the direct connection of the dangerous mains by wires to the negative poles of the generators. A negative feed wire, with branches connected to the low pressure mains, was run by one of the electric railroad companies in Brooklyn. The protective influence of each attachment did not appear to extend beyond a block on each side. It was found to be an advantage to make the connections at the junction of cross streets. The clamp for making the connections consisted of a collar of wrought-iron in two parts, $\frac{3}{8}$ths of an inch thick, and 2 inches broad. The two parts were drawn together by $\frac{3}{4}$-inch bolts, with two nuts to each bolt. The collar was previously turned out upon its inner face to $\frac{1}{4}$th of an inch larger than the diameter of the pipe to which it was to be applied. Midway in one part is formed a lug, into which is braced a No. 00 copper wire. In applying the connection the pipe is carefully brightened all around with a file. A strip of bright lead, $\frac{5}{32}$nds of an inch thick, and $2\frac{1}{2}$ inches broad, is laid around the pipe, and the collar clamped over it till the lead is forced into the inequalities of the pipes. The lines of junction are then painted over with a protective coating.

Prof. A. J. Rowland has recently pointed out the importance of making the earth return of as high resistance as possible. The ties and rails should be bedded in concrete or broken stone to make a poor earth connection, and earth plates should be abolished everywhere over the system.

It will be to the interest of electric tramway and railway companies to adopt similar precautions on their lines in this country; otherwise when the injury to their mains can be so definitely traced to the influence of earth currents, the water and gas companies are not likely to be slow in making claims for damages.

The *Lancet* and Electrocution.

We are compelled to outrage the English language and to coin a new word to express the utterly hopeless condition of our contemporary, the *Lancet*. Over the subject of electrocution as practised in the United States, it has sunk into the most maudlin state of old-womandom that it is conceivable for any leading organ to fall into. We are quite prepared now to learn that it will lead any crazy crusade against any innovation, however common-sensible, for cheap sensation seems to be its leading characteristics whenever it steps out from its hum-drum professional groove, wherein it records leading cases and reports clinical lectures and so forth. In its issue for March 2nd we have it waxing woefully with grief, and actually endorsing the opinion of one, "Dr. Gibbons, an American writer," that more murderers have paid the penalty of their misdeeds on the dissecting table than in the electrocution chair. Apart from the horror of this statement, which is presumably made seriously, we claim that it is inconsistent with all the ascertained facts. What grounds has the *Lancet* for assuming that electrocution does not kill? We are aware that some of the common or garden press of New York have made flaring copy lately in catering for that craving for the horrible which is by no means confined to the other side of the Atlantic. But why does the *Lancet*, a paper posing as the leading organ of up-to-date medicine and surgery, try to make second-hand capital out of such questionable journalese? If further proof were needed, forsooth, the attitude of the *Lancet* is additional evidence of the utter empiricism of medicine. The position assumed by this leading organ is only comparable to that of the medical mysticists of centuries ago. As to whether electrocution does really kill or no let the *Lancet* digest the following fact from amongst others which we could supply: On November 28th the *Electrical World* (N.Y.), in the desire to settle this question, directed a letter to Governor Flower, of New York State, requesting that at the next electrical execution scientific witnesses should be selected whose duty should be to make such observations as would throw light upon the matter. This recommendation was favourably received, and Mr. A. E. Kennelly and Dr. A. H. Goelet were appointed to perform this duty on the occasion of the 24th electrical execution in New York State. As a result of their observations they conclude as follows:—"The evidence is that a current of 8 ampères applied through the body at a pressure of 1,740 volts, and representing a power of 13,920 watts, or about $18\frac{2}{3}$-E.H.P., will produce instantaneous, painless, and absolute death; and that the evidence presented by an examination of the brain alone was sufficient to demonstrate the absolute impossibility of resuscitation." It is probably clear to every mind but the mind of the *Lancet*, that there is no comparison between the conditions attending a deliberate electrocution and those occurring during accidental and momentary contact with a high-pressure circuit. In the latter case means should always be adopted to effect the resuscitation of the victim, and there are reasonable hopes of success; but let the *Lancet* produce a man, or an animal for the matter of that, which, after having sustained the conditions of electrocution, "lives to tell the story." The *Lancet* must know that it is "flogging a dead horse." The burden of its plaint seems to be that the etiquette of *the profession* is being outraged in some obscure way by the attendance of doctors at electrocutions. Yet if these electrocutions were conducted without the presence of a doctor or two, it is certain that the *Lancet* would raise its querulous voice against the iniquity of leaving such a matter in the hands of laymen. As we said in effect before, the *Lancet* has dottered into a hopeless state of old ladyhood, and having reached this stage we must leave it to enjoy the doubtful feminine satisfaction of being hard to please.

New Light on a Point in Maxwell's Theory.

The difficulty that is experienced in understanding Maxwell's notions of "electric displacement" and of "displacement current," has given rise to many contradictory interpretations on the subject of "total current" (*vide* Poincaré, *Electricité et Optique*, t. i., §§ 169—173). This has led Mons. Vaschy to approach the subject apart from the standpoint of any hypothesis, and he has succeeded in so far illuminating it as to demonstrate that the notions referred to are mathematically exact. The means whereby this is effected are purely mathematical, and of such a nature as to be unsuitable for condensation or reproduction in these pages. We refer our readers, therefore, to the *Comptes Rendus*, cxx., No. 5, February 4th, 1895, pp. 254—258.

THE LETHAL EFFECTS OF ELECTRICAL CURRENTS.*

By H. LEWIS JONES, M.D., F.R.C.P.,
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Since the introduction of electric lighting as an industry, fatal accidents have occurred from time to time to those employed in connection with it. These have usually been the result of contacts with conductors charged to a potential of 1,000 volts or upwards, whereby the body of the victim has become the path of a considerable current, discharging in most cases to earth, but sometimes to the other conductor of the system. In ordinary engineering practice these high voltages occur in the mains of the alternate current supply systems, where the pressures range between 1,000 and 2,500 volts. In the case of one London company, the enormous pressure of 10,000 volts is reached. Direct current at high tension also occurs in street lighting by arc lamps, where a number of these are connected in series and worked by a direct current, steady or pulsatory, at a pressure which may amount to 1,500 volts or more. These high potentials are not permitted by the Board of Trade regulations to be used in dwelling houses; and we may say at once that with the pressures (not exceeding 200 volts) which these rules allow in dwelling houses, there is no danger of fatal shocks from accidental contacts with the conductors. The high tension current supplied by the alternating supply companies does not enter the houses, but is used to excite a transformer fixed outside, from which a low tension current is led to the lamps within.

In this country it is the rule that high potential conductors shall be laid underground, consequently the persons exposed to the risk of fatal electric shocks are mainly those employed in the generating or transforming stations, those at work upon "live" high tension mains, or those engaged with "series" arc lamps, and almost all the accidents which have occurred in this country have been to persons engaged in one or other of these ways. Where high pressure wires are allowed on poles overhead there is a chance of the wires breaking and falling down among the people in the street, and deaths have been caused to several persons abroad through incautiously meddling with such wires. The two accidents lately recorded, in which a creeping discharge along the surface of the ground has proved fatal to horses, are of peculiar interest, but are not so likely to cause serious damage to human beings; still it is to be hoped that they will not often recur.

The mode in which electric shocks cause death is one of considerable interest, because it underlies the questions of the prevention of such accidents and of the mode of treatment when they arise. Recently, attention has been called to this question afresh by the writings of Prof. D'Arsonval on the subject, which has given rise to much discussion in the technical journals and in the public press. His belief is that it is not the heart but rather the respiration which fails. He has even declared that in his opinion the criminals executed by electricity in the United States died from the effect of the *post-mortem* examination; that the shocks had only rendered them insensible, and that they might have been revived by artificial respiration.

Other writers following him have lamented the deaths of other victims of electricity, which they consider might have been prevented by timely assistance. A case has even been recorded† in which a man was resuscitated in this way when he was apparently dead, although the artificial respiration was not commenced until three-quarters of an hour after the accident. Too ready an acceptance of D'Arsonval's theory is likely to be a source of danger, by leading people to think less of the risks of electric shock, and already an American medical man is said to have offered to submit to an electrical discharge provided only that his special method of resuscitation be carried out upon him afterwards.

Against D'Arsonval's views we would note that artificial respiration has been employed in vain in some of these accidents, and that in the *post-mortem* examinations upon the American criminals the heart was not found beating—I write from memory, not having a report at hand—although the necropsy was begun immediately after the execution; in fact, the stoppage of the heart's action was taken as the sign of the patient's death.

In a case reported by Dr. J. W. Brown in the *New York Medical Record*, 1893, the victim survived the first shock, the dynamo breaking down, and he began to recover. The published account states that the current was kept on for 52 seconds; the man remained apparently dead for 20 seconds more, and then gasped; five seconds later no pulse could be felt at the wrist, but after 30 seconds it was felt, breathing became gradually re-established, the pulse grew stronger, and some movements of a purposive nature were performed. He was then killed by a shock from an arc lighting machine. In this case the heart and respiration were both profoundly affected. Respiration recovered first, and then the heart.

In a report by Dr. Clowes* of an accident in Brompton, the patient was seen five minutes after the accident. The heart and respiration had stopped; artificial respiration was performed, but was of no use. In D'Arsonval's case, referred to above, three-quarters of an hour had elapsed before artificial respiration was begun, and it seems unlikely that respiration could have been completely arrested for so long a time and the patient not die. It is probable that the man was in a dazed or senseless condition only, and might have come round equally well without artificial respiration.

The examination of the bodies of those killed by electric shock may afford little information as to the mode of death. In one of the earliest cases† recorded in the medical journals, no signs of injury could be found except a small superficial burn of the thumb. It is usual to find some marks of burning at the part which has been in contact with the wire or point of entry of the current, and a careful search should always be made over the whole body for other burns at the point (point of exit) at which the current passed from the patient to the earth or to the other conductor. When the discharge has been to earth the current usually leaves the body at the feet, and these should always be examined for marks of burning, and the soles of the boots should also be looked at. When the shoes and socks are damp there may be no burn of the feet, even when a current of fatal magnitude has passed through them. The soles of the feet and the socks are almost always damp from perspiration, and the soles of the boots of working men are often full of nails; the boots, therefore, offer but little in the way of insulation resistance. The severity of the burns is to be taken rather as a measure of the duration of the contact than of the magnitude of the fatal shock, and the same may be said of the heating of the tissues which has been sometimes observed. They may be slighter in those who have been killed on the spot than in those who have escaped with their lives. When the body remains in circuit, burns of great extent may be caused by the prolonged action of the current upon it subsequent to death.

In the accounts of the necropsies mention is often made of congestions, extravasations of blood, or internal hæmorrhages; these may be the result of violent muscular tetanus caused by the shock and the rise in blood pressure associated with it; they are not themselves the cause of death. It is difficult to assign its proper value to the statement which so often crops up about the fluidity of the blood in these cases. The heart is often noted to be relaxed and empty, and this is not in accord with the theory of death from asphyxia. For electric shock to cause death a current of considerable magnitude must pass through the body and must traverse a vital part. An extremity may be completely destroyed by a current without the patient himself being killed by the shock, provided that the current does not pass through the trunk as well. It is not volts which kill, and in this lies a common source of error; people are said to have received so many volts, which tells one very little; whereas if we could be told what ampères or current had passed through them, the cases of shock would soon arrange themselves in order, and the magnitude of the current required to kill would be no longer a speculation.

The voltage of the source of electricity determines the magnitude of the current through the patient; but another factor,

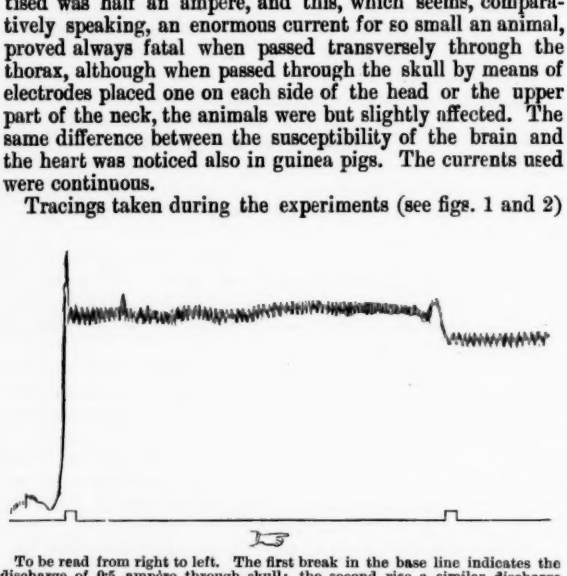
* From the *British Medical Journal*.
† *Comptes Rendus*, Vol. xcviiii.

* *Lancet* of December, 1892.
† Sheild and Delépine, *British Medical Journal*, i., p. 531.

the resistance of the patient, is equally important. By the resistance of the patient is understood the resistance through the patient's body, his clothing or boots, and, in the case of a discharge to earth, of the floor on which he is standing. When protected by trustworthy and adequate resistances a man may take hold of a conductor of high potential unharmed, and in cases of accidental shock, the dampness or dryness of the boots, or of the floor on which a workman stands, may easily make the difference between life and death. In general the magnitude of the current traversing the tissues can hardly be even roughly guessed at from a knowledge of the voltage of the conductor, because the resistance of the path through the patient may be of almost any magnitude; in fact, no definite answer has yet been given to the question what current is required to kill a man, though probably the minimum current is over half an ampère. The body may be traversed from hand to foot by a current large enough to cause extensive and deep burns, without a necessarily fatal result. The vigour of the patient's heart is most likely an important factor in the case. Experiments on animals have been made by several observers. Dr. Tatum, of New York, published in 1890* some results of his experiments on dogs, which are valuable. He made use both of alternating and continuous currents. The current required to kill varied with the size of the animals, and ranged from 0·1 to 1·3 of an ampère. Alternating currents seemed to be twice as fatal as continuous, but under ether this difference became much less marked; the periodicity of the alternating current seemed unimportant; the anæsthetic increased their chances of survival to a considerable extent with alternating currents, though not with continuous. The path of the current in his experiments was between the skull and the thigh. He came to the conclusion that the fatal mischief done by electrical currents to dogs is done chiefly or entirely within the actual substance of the heart.

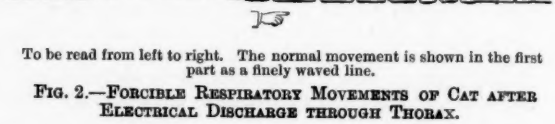
In some experiments carried out in the laboratory of the Royal Colleges of Physicians and Surgeons by Mr. Bokenham, which I was enabled to witness through his kindness, the current required to kill cats which were deeply anæsthetised was half an ampère, and this, which seems, comparatively speaking, an enormous current for so small an animal, proved always fatal when passed transversely through the thorax, although when passed through the skull by means of electrodes placed one on each side of the head or the upper part of the neck, the animals were but slightly affected. The same difference between the susceptibility of the brain and the heart was noticed also in guinea pigs. The currents used were continuous.

Tracings taken during the experiments (see figs. 1 and 2)



To be read from right to left. The first break in the base line indicates the discharge of 0·5 ampère through skull; the second rise a similar discharge through thorax.

Fig. 1.—Blood-pressure Tracing of Cat.



To be read from left to right. The normal movement is shown in the first part as a finely waved line.

Fig. 2.—Forcible Respiratory Movements of Cat after Electrical Discharge through Thorax.

showed conclusively that death was caused by failure of the heart, and the negative results of shocks of equal strength through the head and neck suggest strongly that the action is upon the heart muscle rather than upon its nervous mechanisms. Experiments by Dr. Tatum on animals under atropine and with divided vagi point in the same direction. Though carefully tried, in no case could the animal be revived by artificial respiration when apparently dead. Indeed, the stoppage of the heart was always followed by a period of dyspnœa, with very forcible spontaneous respirations, due no doubt to the action of the respiratory centre, stimulated by the sudden failure of the supply of arterial blood which followed the stoppage of the heart; and it is interesting to note that a similar condition of laboured breathing has been recorded in some of the cases of accidents from electric shock. An examination of the animals' hearts showed them relaxed, with tremulous movements of the auricles and auricular appendices; by no stimulation of the exposed heart could it ever be made to beat again. These experiments show clearly that the effect of the shocks was to arrest the hearts' action, while respiration was not seriously affected; nor with the animals employed, and under the conditions of the experiment, was any state observed of suspended animation or apparent death from which the animal could be restored by artificial respiration. When the shocks through the thorax were insufficient to stop the heart, its action became feeble for a time, but quickly recovered. Respiration was somewhat altered in rhythm, though not profoundly so. The results, in fact, are directly opposed to the views expressed by D'Arsonval. It is possible that the effect in man may be different from that in cats and in guinea pigs, and it is not unlikely that there may be a stage on the borderland between life and death, with the patient rendered insensible, but with the heart's action not completely arrested, and, in these, artificial respiration might be of some service. Certainly it should always be tried if the patient's heart is still beating. Although the labours of D'Arsonval upon matters connected with the physiological actions of electricity entitle his views to our highest respect and attention, I cannot help believing that upon this question he may be mistaken, and I fear that death in the victims of severe electric shock is too often real, not apparent, and that they are, as a rule, quite beyond resuscitation by artificial respiration, or by any other means with which we are acquainted. In fact, it is certain that electrical discharges can kill a man as dead as a doornail. The majority of the fatal accidents have been due to discharges from one conductor to earth through the body; of 15 cases of which I have notes, 10 were certainly, and some of the others were, probably, of this nature. This makes it important to consider what step can be taken to protect workmen from such accidents. An obvious method is to insulate them from the ground, and it seems that this might best be done by covering the floors of all high-pressure stations and sub-stations with a thick layer of asphalte, or with insulated platforms of considerable extent, and by covering the walls, as far as possible, with a non-conducting lining of wood, the insulating resistance of which might be increased by impregnating it with paraffin wax, or tar or varnish. The arrangements should be such as to make it impossible for a workman to touch any high potential conductor or machine, except when he stands upon a non-conducting surface, nor should he be able to touch at the same time a high potential conductor, and any part of the building which is in electrical connection with earth. In the case of men at work through unavoidable necessity upon "live" high-pressure street mains or arc lamp circuits, it is probable that the use of India-rubber sea boots without nails would be a better protection than the rubber gloves, which have been several times found lacking; at least, the use both of boots and of gloves would decrease the risk. The danger of street mains, however, is best met by permitting no work to be done upon them until they have been cut-out of circuit. When, unfortunately, an accident has happened, artificial respiration should be put in practice as soon as possible, in the hope that the injury has not been severe enough to arrest the heart permanently; and if the heart show signs of beating, however feebly, the artificial respiration must be persevered in. By the enterprise of the Electrical Review, a card of directions for the best method of giving first aid to victims of electric shock has been issued, and is likely soon to find a place in all central stations. It is drawn up on the lines of the well-known card of the Royal Humane Society for the restoration of the apparently drowned.

* The *Electrical World*, May 10th, 1890.

TRANSMISSION OF POWER.

Before the Institution of Civil Engineers on Tuesday, the 5th inst., two papers, dealing with the transmission of power by electricity, were read. The first on "Electrical Haulage at Earnock Colliery," by Mr. Robert Robertson, B.Sc., M.Inst.C.E., opened with an account of the general features of the colliery and of those of its seams into which electrical haulage had been introduced. The arrangements of the shafts and the capacities of the cage and coal-hutches were such that the daily output amounted to 1,200 tons. Details were given of the lengths and gradients of the main haulage roads in the Ell and Main coal seams, and of the two steam hauling engines operating those roads, on the main and tail, and endless rope systems respectively. Electrical hauling engines had been introduced to drive endless ropes, and to replace horse traction between the main haulage roads and the working faces.

The electrical generating plant comprised a dynamo for supplying power to the electrical hauling engines, capable at a speed of 620 revolutions per minute of an output of 100 ampères at 490 volts. It was driven from a shaft coupled direct to two single-acting Westinghouse engines, having cylinders 13½ inches in diameter, with a length of stroke of 12 inches, and developing together, when running at their normal speed of 350 revolutions per minute, 122 H.P. with a steam pressure of 50 lbs. per square inch. The electrical circuits were metallic throughout, and the conductors were highly insulated, being sheathed also in iron pipes in the shaft and supported upon insulators in the workings.

The two electrical hauling engines, of which the main features were similar, were next described and illustrated. The motor of the engine in the Ell coal seam, when running at a speed of 770 revolutions per minute, developed 35 H.P. with a current of 76 ampères at a pressure of 400 volts. It was geared, through an intermediate shaft, to two pulleys with Hurd clips, each provided with a friction clutch and brake, by which the cables were driven at a speed of 3 miles per hour. The two cables were of stranded steel wire ¾-inch in diameter, and, after passing over balance wheels placed in recesses near the engines, operated circuits of 2,160 yards and 1,020 yards in length respectively. The cables were supported at intervals of about 30 feet along the roads by rollers 4½ inches in diameter; and at the corners were passed over wheels 5 feet in diameter, mounted upon vertical axes below the level of the rails. The gradients were so arranged at the corners that the trains of trucks could there travel without aid from the ropes. In the Main coal seam a cable operated similarly a circuit 1,580 yards in length. The cables were driven continuously at a uniform speed, and the coal-hutches were attached to or detached from them by a Smallman clip.

The efficiency of the plant as compared with the horse traction, which it had replaced, was then considered. The electrical haulage system in the Ell coal seam was capable of a daily output of 400 tons. The daily output by horse traction had been 180 tons, and to increase this to 400 tons, 30 or 40 horses would have been required, a number which could not have been employed in the available space without confusion. The daily output of the electrical haulage system in the Main coal seam, which was not yet working at its full capacity, was between 150 to 200 tons.

The yearly working expenses of the two systems were compared, upon the results of one and a half-year's working, and were found to be £4,130 and £1,990 by horse traction and by electrical haulage respectively, showing that an annual saving of £2,140 had been effected by the latter. The total cost of the electrical installation had been £3,500.

In the second paper—"Water Power applied by Electricity to Gold Dredging," by Mr. Robert Hay, M.Inst.C.E., an account was given of plant which had been erected in New Zealand to utilise water-power for generating electricity to be transmitted to motors operating a dredge in different portions of a distant river. The author pointed out that the transmission of water-power by electricity, in well-watered countries like New Zealand, rendered available deposits of gold in districts in which the scarcity of fuel would not permit of their being worked by other means. The plant described had been constructed for gold-dredging in the River Shotover, the course of which was for the most part in rocky gorges through rugged country, accessible only by tracks cut down the leading spurs and gullies.

The source of the water-power and the method of its application were then described, and illustrated by a longitudinal section of the pipe-line. The water was obtained at a creek 1½ mile distant from the dredging ground, and was brought by a race cut in the side of the hill, or, in places where the ground was not suitable, in a timber flume, to a pressure-tank at a level of 524 feet above the pipes at the generator-house. From this tank to the Pelton wheel the water was carried in rolled steel pipes, constructed in lengths of 19 feet 6 inches, bolted together by wrought-iron flanges riveted to the pipes.

The prime mover of the generating plant was a 4 foot Pelton reaction water-wheel, upon the buckets of which the water, from a nozzle 1½ inch in diameter, impinged at a pressure of 228 lbs. per square inch. This wheel drove two series-wound dynamos working at a normal speed of 700 revolutions per minute, each developing a current of 40 ampères at an electromotive force of 650 volts, or together nearly 70 H.P. The dynamos were coupled in series, and to guard against damage from abnormal increase of current, a regulator was so arranged as to throw into the circuit an artificial load, in case of the current becoming from any cause 3 ampères greater or less than its normal amount. The conductors, of a length of 2 miles, were of No. 4 S.W.G. bare copper wire, and were supported upon insulators carried by cross-arms upon old 40 lb. rails.

The current was conducted to two motors in the dredge, one for driving a centrifugal pump and the other for operating the buckets, winches, and revolving cylinder. These two machines were duplicates of the dynamos and were coupled in series so that when the bucket motor was switched off, the pump motor absorbed the surplus power by increasing the speed of the pump and causing it to throw more water.

The dredge was constructed for the most part of steel, and was capable, when operating at a depth of 20 feet, of an output of 90 cubic yards per hour. The dredgings were delivered, through a revolving screen for separating the stones and coarser material, upon baize tables set at an inclination of 1 in 12. Two 10 ampère arc lamps lighted the dredge at night, and were joined in multiple series with the motors, with suitable arrangements for their control. A table of particulars of the efficiencies of various parts of the plant was was given. The cost of the installation and the weekly working expenses, £7,000 and £35 respectively, were also tabulated.

WAVES AND VIBRATIONS.

Lord Rayleigh opened a series of lectures under this title on Saturday the 2nd inst. In the preliminary announcement, the subject had been declared as "Sound and Light," but it will be remembered that the latter branch of physics was fully dealt with this time last year. Sound had also been the subject of a similar course at a still earlier date. In treating "sound" quick and minute vibrations which appeal to the ear are considered. Lord Rayleigh proposes in this course to take up waves of much greater length. Whereas in light the waves are of high frequency, there are many points common to all kinds of waves, to sound waves as well as any other. The term "wave" has a specific meaning, and also it is desirable to clearly define what is meant by "progressive waves." The path of a wave is not always the same, sound waves usually travel in air, although wood and metal also convey waves which are of this nature. Waves may, however, travel in a medium very different from ordinary matter. When a wave is said to travel, the transference of matter is not necessarily implied, although the wave form does move, say, from right to left. The simple definitions of the principal quantities which determine a wave motion are the wave length, periodic time, and velocity of propagation. The wave length is the distance from crest to crest; whether the wave be large or small, high or low, has nothing to do with its length. The distance from a crest to hollow is a half-wave. The periodic time is the time in which each part constituting the wave takes to go through the cycle of its changes. It is therefore the time between two successive maximum variations. The wave length is then the distance which the wave travels in a time

equal to the periodic time. Any kind of light may be measured by stating the wave length and frequency.

The velocity of propagation of sound waves is about 1,100 feet per second, and all sound waves move with the same speed. The velocity of propagation of a wave in air is independent of the wave length. In the case of water waves, velocity is *not* independent of the wave length, long waves travel more quickly than short ones. This may be expressed by writing, $v \propto \sqrt{\lambda}$. Early in the present century several French physicists investigated this problem, which does not require abstruse mathematical demonstration, depending as it does upon the principle of dynamical similarity. An analogy could be drawn from a musical performance performed at various speeds, the time would be varied but the cycles would be similar. Waves at sea, *i.e.*, water waves, are principally generated by wind, other causes are earthquakes and occasionally by barometric disturbances. The production of waves by air currents was shown by an experiment in which an electric fan was used to drive a current of air upon the surface of water contained in a long glass-sided trough. Waves of short length were created near the fan and those of longer length a short distance down the trough. The latter finally became preponderant. The action of oil was shown and it was explained that its effect was to give stiffness of a capillary character to the surface of the water, and short waves find it more difficult to maintain themselves. Waves propagate themselves and form breakers on adjacent coasts, but they are not all propagated at the same speed. There is a selective tendency for those of long wave length to precede and those shorter to follow. If the periodic time be known it is quite a simple matter to calculate everything else. Ten seconds period is about the maximum reached; Lord Rayleigh has himself observed waves of this periodic time breaking upon the north side of the island of Madeira. Only four or five such waves would go to the mile. The height, of course, could not be foretold from a knowledge of the period alone. Height is often exaggerated, 40 feet from hollow to crest is probably the

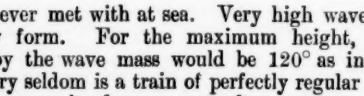
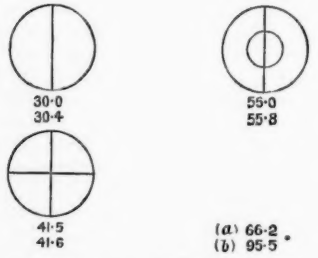


Fig. 1.

maximum ever met with at sea. Very high waves lose the undulatory form. For the maximum height, the angle included by the wave mass would be 120° as indicated in fig. 1. Very seldom is a train of perfectly regular waves met with, the wave as it advances very often seems to change its character. The velocity of a group of waves differs from that of any individual one, say usually as 2 : 1. The wave



In right-hand column 55·0 should read 56·0.

Fig. 2.

in the middle seems to run through the group and get in advance, the velocity of any individual one is greater than that of the group. Enough energy is not otherwise propagated, the converse applies to other specific cases.

Another class of waves is familiar to students of acoustics. These are stationary waves which form on the meeting of two trains of oppositely directed progressive waves. Some examples of these were shown in a large circular tank. This might have been swayed from side to side; on a certain diameter the water would not have moved up and down at all, this being the nodal diameter. Another mode of vibration would give two nodal diameters, and yet others more complex vibrations. In any case the whole motion of the water would be symmetrical about the centre. The figures attached show the observed (above) and calculated (below) periods of vibration for the different cases, the lines and circles representing the nodes. In the experiment shown the second case was taken first, the calculated and observed periods practically agreed being 66·2 complete vibrations per minute. The first case was then tried, for this calculation gave 95·5 ~ per minute, experiment resulted in 100 ~ per minute.

Lord Rayleigh then proceeded to some points of practical importance. In the case of warships and passenger vessels it is necessary to diminish rolling as much as possible, and to prevent it accumulating. A "stiff ship" has its best example in a raft, whereas a "steady ship" is one which keeps nearly vertical in spite of the wave motion. Great stability or stiffness is not advisable; a little tendency to top heaviness makes a ship steadier. Modern warships have a natural period of rolling greater than that of any waves they are expected to meet, but the progress of the ship through the water may also bring about the coincidence of vibration which is so much to be avoided. To treat the question thoroughly involves the use of Bessel's functions; it has been experimentally examined by Mr. Froude some years ago.

The third class of waves, "standing waves," are more analogous to progressive than to stationary waves. A wave in a watercourse may progress relative to the water, but remain stationary with relation to an observer on the land. These are, in many cases, capillary waves, because they depend more on the capillary tension than upon gravity; when λ (the wave length) is equal to 1·7 cm. the two causes are equally important. Lord Kelvin first gave the theory of capillary waves. The velocity of propagation becomes a minimum when λ has a value, the corresponding velocity for which is 23 cm. per second. Two values will do it, one longer, due to gravity, another shorter operated by the capillary tension. Thus there are two sets of waves with different wave lengths, both of which can be propagated at the same speed. The wave length has to be accommodated to the obliquity of path.

Judging from the apparatus on the lecture table, Lord Rayleigh intends to deal very thoroughly with the subject of these lectures. In view of the importance of wave motion, a popular exposition of the subject must be of great value, and we look forward with interest to the remaining meetings on the next four Saturday afternoons.

THE STORAGE OF ENERGY ESSENTIAL TO ECONOMY OF WORKING IN CENTRAL STATIONS*

By N. W. PERRY, E.M., New York.

The Committee on Data reporting at the Washington meeting stated that 1·5 lb. of coal per indicated horse-power, with a combined engine and dynamo efficiency of 81 per cent., would produce 402·84 watt hours per pound of coal. In the tabulated statement of data collected by this same committee, the highest results of practice given were 208 watt-hours per pound of coal. The next highest was 192, the lowest 25, and the average 91·7 watt-hours, or only 22·7 per cent. of that which the best practice under favourable conditions should give.

* Read before the National Electric Light Association at its 18th Convention, held at Cleveland, Ohio, February 19th, 20th, and 21st, 1895.

By far the larger number of stations reporting are small ones, in which the highest economies would not be expected, and we find, as a matter of fact, that most of these report results below the average. Discarding all results based on a consumption of less than 10,000 lbs. of coal, we have an average for the largest stations of 127·7 watt-hours per pound of coal. This is equivalent to a consumption of about 5 lbs. of coal per indicated horse-power. The best results given (208) are equivalent to about 3 lbs. per indicated horse-power, or more than twice as much as the machinery involved requires for the best results. Bad as this showing is, it seems to compare favourably with foreign practice, for Prof. Unwin says:* "Probably up to the present (1893), the consumption has in no case been less than 3·3 lbs. per indicated horse-power."

When we consider how enormously short the results of actual practice in lighting stations are of those which are obtainable under the most favourable conditions with the same machinery, it behoves us to inquire into the cause of this deficiency, and to see how far we can remedy it.

Prof. Kennedy has made some very careful tests to indicate the effect of variable load upon coal consumption. Dividing the day into three portions, he determined the fuel consumption, the feed water evaporated, and the indicated and electric horse-power developed during each period in an English lighting station. It will be seen that during the periods of light load the fuel consumption per horse-power is very large.

Coal Consumption in Boilers with Variable Load.

	11 a.m. to 6 p.m. 7 hours.	6 p.m. to midnight. 6 hours.	Midnight to 11 a.m. 11 hours.	Mean for 24 hours.
Total I.H.P. hours	562	1,366	407	...
Total E.H.P. hours	400	979	260	...
Coal per I.H.P. hours pounds	6·88	3·26	6·26	4·65
Coal per E.H.P. hours pounds	9·67	4·55	9·80	6·62
Pounds water evaporated per pound coal...	5·92	9·60	9·27	8·21
Pounds water per I.H.P. hour	40·7	31·3	57·7	38·3
Pounds water per E.H.P. hour	57·2	43·8	91·0	54·4

Comparing the consumption of steam and coal during mean load with that during the hours of heavy load (6 p.m. to midnight) we find that the mean steam consumption per electric horse-power hour was 24 per cent. greater, and the mean coal consumption per electric horse-power-hour was 46 per cent. greater—the difference of 22 per cent. being attributable to waste at boilers, due to irregular working. During the whole 24 hours the mean evaporation in pounds of water per pound of coal was only 85 per cent. of the evaporation during the period of maximum load.

Captain Sankey has applied Mr. Willans's formula to find the steam consumption of one or more engines working against a variable load in an electric lighting station. He takes a normal midwinter load curve, and examines how the necessary current could be supplied during the 24 hours (1) with an engine capable of exerting the maximum power required; (2) with smaller engines. The results, rearranged and a little modified, are given by Unwin in the following table. It is assumed for convenience that the maximum load is 500 electric horse-power, and that the engines are non-condensing.

Steam Consumption in Engines Working with a Variable Load.

	Average load factor.	Steam consumption in pounds per average electrical horse-power-hour.	Per cent. increase of steam consumption due to variable load.
1. 500 E.H.P. engine ...	0·22	50	108
2. 200 E.H.P. engines ...	0·49	34·5	44
3. 100 E.H.P. engines ...	·65	29·5	23

We thus see how closely these results agree with Prof. Kennedy's figures, derived from direct tests, which gave 24 per cent. increased consumption at mean load over that at maximum load.

* "On the Development and Transmission of Power," page 28.

The efficiencies of engines and dynamos in lighting stations are maintained quite high, notwithstanding the variable output of the establishment, by throwing in and out units as the load varies, so that at most only one unit need be working at less than its best load, and the variation in efficiency of this one unit is chiefly due to the larger proportion of the whole that the friction losses bear at light load. Almost the whole loss of efficiency, *due* to variable load, is, therefore, attributable to the boiler.

There is still another class of losses which is not amenable to calculation, viz., those due to leaks from boiler fittings and steam pipes, with condensation losses in the steam pipes, and due to the wasteful use of steam by all present known means of boiler feed. As these losses continue practically constant throughout the 24 hours, they assume especial importance where the load factor is low.

To show more clearly at what relative cost we produce power in our lighting stations with their variable loads, and under other commercial conditions where the lead is fairly constant, I quote Prof. Unwin:

1. *Engines working on a very regular load, in conditions similar to those of an engine pumping to a reservoir.*—Here, for one effective horse-power exerted during 7,884 hours annually, engines of 1·47 indicated horse-power must be provided. Such engines may be taken to use 14 lbs. of steam per indicated horse-power-hour in test trials, but in ordinary work 7½ per cent. more must be allowed for leakage, working auxiliary engines, and less careful attention; this makes the consumption 15 lbs. per indicated horse-power, or $15 \times 1{,}176\ (\frac{1}{85}) = 18$ lbs. per effective horse-power-hour. At 9 lbs. of steam per pound of coal, allowing also 5 per cent. for lighting and banking fires, the engine would use 2·1 lbs. of coal per effective horse-power-hour.

Cost of Installation per Effective Horse-Power.

Cost of engines or with reserve 1·47 indicated horse-power = 1·47 × $44·5	$65.42	
Cost of boilers = 1·47 × $24	35.28	
Cost of buildings = 1·47 × $30	44.10	
Total		$144·80

Annual Cost of Working per Effective Horse-Power.

Interest on $144.80 at 4 per cent.	$5.79	
Maintenance and depreciation—buildings at 2 per cent.	·88	
Machinery at 7½ per cent.	7.61	
Total fixed annual cost		$14.28
Coal 2·1 lbs. for 8,760 hours at $1.75 per ton... ...	$16.10	
Petty stores	1.64	
Driving, stoking and cleaning	11.67	
		29.41
Total annual cost		$43.69

Steady Working Cost of 1 Electrical Horse-Power.

Cost of engines, 1·547 at $44.5	$68.84	
Cost of boilers, 1·547 at $24	37.13	
Cost of dynamo, one at $30	30.00	
Cost of buildings, 1·547 at $30...	46.41	
	$182.38	
Interest on $182.38 at 4 per cent.	7.30	
Maintenance and depreciation—buildings at 2 per cent.	93	
Machinery at 7½ per cent.	10.20	
Total fixed annual cost		18.43
Cost of coal, 2·21 lbs., 8,760 hours, at $1.75 per ton...	$16.94	
Cost of petty stores	1.64	
Cost of driving, stroking and cleaning	11.67	
		30.25
Total annual cost per electric horse-power		$48.68

2. *Engines working with variable load under conditions similar to those of an electric lighting station.*—Here, for one effective horse-power supplied on the average throughout the year, engines of 5·87 indicated horse-power have to be provided. On account of the inefficiency and waste, due to variation of the load, it is best to estimate the steam and coal from experience in similar cases. Probably no electric lighting station at present works with quite so low a consumption as 6 lbs. of coal per hour per electrical unit supplied. A consumption of 9 lbs. is probably much more common in the best managed stations. 6 lbs. of coal per electrical unit corresponds to 3·8 lbs. per effective horse-power-hour.

Cost of Installation.

Cost of engines for 1 average effective horse-power with reserve, 5·87 indicated horse-power = 5·87 × $44.5	$261.22	
Cost of boilers = 5·87 × $24	140.88	
Cost of buildings = 5·87 × $30	176.10	
Total	$578.20	

Annual Cost of Working per Effective Horse-Power.

Interest on $578 20 at 4 per cent.	$23.13	
Maintenance and depreciation machinery at 7½ per cent.	30.25	
Buildings at 2 per cent....	3.50	
Total fixed annual cost		$56.88
Cost of coal, 3·8 lbs. for 8,760 hours, at $1.75 per ton	$26.00	
Cost of petty stores	1.64	
Cost of driving, stoking and cleaning...	11.67	
		39.31
Total annual cost		$96.19

In other words, our power costs us 2,138 times as much in an electric light station as it should. If we figure out the relative costs per electrical horse-power, the disparity will be still greater.

Using these same data, but carrying the results out to electrical horse-power, assuming a dynamo efficiency of 95 per cent., we have 4 lbs. of coal per electrical horse-power.

Cost of Installation per Electrical Horse-Power.

Cost of engines, 6·17 × $44.5	$274.56	
Cost of boilers, 6·17 × $24	148.08	
Cost of buildings, 6·17 × $30...	185.10	
Cost of dynamos, four, at $30	120.00	
Total	$727.74	
Interest on $727.74 at 4 per cent.	$29.11	
Maintenance and depreciation machinery, $542.64, at 7½ per cent.	40.70	
Buildings, $185.10, at 2 per cent.	3.70	
Total fixed annual cost		$73.51
Cost of coal, 4 lbs. for 8,760 hours, at $1.75 per ton	$30.63	
Cost of petty stores	1 64	
Cost of driving, stoking and cleaning	12.00	
		44.27
Total annual cost electric horse-power ...		$117.78

When we compare this with the cost resulting from steady working, viz., $48.68, we see what an effective method of storage means in our central stations. If our storage costs us nothing, it would result in a saving for each electrical horse-power generated per year of $117.78 − $48.68 = $69.10. But any system of storage which we may employ will involve expenditures, both in the way of losses in storage, which will have to be provided against by the increased plant to provide for the same ultimate output, and in the way of interest on the additional investment required by the storage plant. As a matter of fact, these additional costs must in all cases be less than the saving otherwise effected, else we are paying more for our economy than it amounts to. In the present case, our storage must cost us less than $69.10.

If we could take the variable load off between the boiler and engine, viz., devise some means by which the same amount of energy could be supplied by the continuous operation of a boiler plant working at its most economical rate, we would at once do away with one of the most serious losses due to irregular working. Let us see how much the saving would be if the irregular working of the boilers could be obviated without cost :—

Cost of engines, 6·17 at $44.5	$274.56	
Cost of boilers, 1·547 at $24	37.13	
Cost of buildings, four, at $30	120.00	
Cost of dynamos, four, at $30	120.00	
Total	$551.69	
Interest on $551.69 at 4 per cent.	22.07	
Maintenance and depreciation machinery, $431.69, at 7½ per cent.	32.38	
Buildings, $120, at 2 per cent.	2.40	
Total fixed annual cost		$56.85
Cost of coal, 2·21 lbs. for 8,760 hours, at $1.75 per ton	$16.93	
Cost of petty stores	1.64	
Cost of driving, stoking and cleaning	11.67	
		30.24
Total annual cost per electrical horse-power		$87.09

If the storage cost us nothing, and was applied between the boiler and the engine, it would effect a saving of $117.78 − $87.09 = $30.69. The limiting expense, therefore, to which we can go for storage at this point is $30.69 per annual electrical horse-power.

If we move our storage forward one step and introduce it between our engine and dynamo, so that everything previous to the dynamo would work continuously at its maximum economy, the account would stand thus :—

Storage between Engine and Dynamo. Cost of 1 Electrical Horse-power.

Cost of engines, 1·547 at $44.5	$68.84	
Cost of boilers, 1·547 at $24	37.13	
Cost of dynamos, four, at $30	120.00	
Cost of buildings, four, at $30	120 00	
Total	$346.97	
Interest on $346.97 at 4 per cent.	$13.86	
Maintenance and depreciation machinery, $226.97, at 7½ per cent.	17.02	
Buildings, $120, at 2 per cent....	2.40	
Total fixed annual cost		$33.28
Cost of coal, 2·21 lbs., 8,760 hours, at $1.75 per ton...	$16.94	
Cost of petty stores	1.64	
Cost of driving, stoking and cleaning...	11.67	
		30.25
Total annual cost per electrical horse-power		$63.53

The saving by introducing storage at this stage would be $117.78 − $63.53 = 54.25, or a gain by moving the storage forward one step of $54.25 − $30.89 = $23.56. If we move it forward still another step, and bring it between the dynamo and distribution, we have an additional possible gain of $69.10 − $54.25 = $14.85.

Recapitulating, we have possible gains by introducing the storage by successive steps forward :—

		Cost of horse-power at this stage.
Between boiler and engine	$30.69	$48.68
Between engine and dynamo	23.56	87.09
Between dynamo and distribution ...	14.85	117.78
Total	$69.10	

Battery Storage.

Supposing, in the case assumed, we endeavour to equalise the load by means of the storage battery. This will allow the boilers, engines and dynamos, to work continuously at their most economical rate, and would seem to provide ideal conditions of working. We are not, however, storing the product, we have to sell as is the gas manufacturer—we are not storing electrical energy, as some suppose, but chemical energy, which must be transformed again into electrical energy before we can distribute it. These two transformations, of course, involve a loss of energy which must be provided for in boilers, engines and dynamos, and also in coal. To be entirely fair with the storage battery, let us assume that its efficiency under all conditions is 75 per cent. Then in order that we may have at average working 1 electrical horse-power, we must provide :—

Boilers, $\frac{1·547}{·75}$ = 2·07 at $24	$49.68
Engines, $\frac{1·547}{·75}$ = 2·07 at $44.5	92.12
Dynamos, $\frac{1}{·75}$ = 1·333 at $30	40.00
Buildings, say	125.00
Total investment, without storage battery	$306.80

If we are to produce an average of 1 electrical horse-power per hour, we will produce 24 horse-power-hours during the 24 hours, half of which must be stored, viz., we must have storage battery capacity for 12 horse-power-hours. Of course, the rate of discharge will have some bearing upon the cost of this storage battery capacity, but taking an abstract case, we may assume, I think, without being unfair, that it will cost $35 per electrical horse-power hour capacity erected. We must, therefore, add to our former figures, 12 × $35 = $420, which is more for the batteries than we have allowed

for all the rest of the plant put together, including the buildings :—

The total fixed investment, therefore, becomes $726.80		
Interest on $726.80 at 4 per cent.	$29.07	
Maintenance and depreciation		
Buildings, $125 at 2 per cent.	2.50	
Machinery, $181.80 at 7½ per cent.	13.64	
Storage battery, 420 at 10 per cent.	42 00	
Total fixed annual cost		$87.21
Coal, 2·95 lbs. for 8,760 hours, at $1.75 per ton ...	22.61	
Petty stores, attendance, &c.	13.31	35.92
Total annual cost per electrical horse power ...		$123.13

which would be an actual loss over that of irregular working of $123.13 — $117.78 = $5.35. It will cost with the storage battery thus used $123.13 — $48.68 = $74.45 more than the same machinery working continuously on a steady load could produce it for.

If we assume coal to cost $3.50, instead of $1.75, the cost per electrical horse-power will be :—

Steady load without storage battery	$52 31
Variable load without storage battery...	148.40
With storage battery	145.74

This does not condemn its use in central stations in other ways, however, for there are many cases in which its use may contribute to economy, but these cases cannot be determined by any general rational formula. Each case must be determined for itself, and the result will depend, primarily, upon the shape of the load line, and, secondarily, upon the ability of the battery to rise above normal discharge rate economically. In the case of a station previously equipped, without storage, so that the units are already determined, the question of economy of introducing storage batteries will be determined in some cases entirely by the sizes of those units.

(To be continued.)

BLAST FURNACE MOTOR GAS.

By W. H. BOOTH.

There are waste products in most industries, but in no industry is waste more striking than in the smelting of iron ore. Of the coal used to smelt iron, how much is found in the iron itself after being run from the furnace? Somewhere about 80 pounds per ton of iron. The calorific capacity of a pound of coke is, say, 14,500 thermal units. Assuming that pig iron runs from the furnace at a temperature of 1,800 degrees F., and that the specific heat of iron is ·114, each pound of iron will carry off 205 heat units. Now, with a consumption of 25 cwts. of fuel per ton of iron produced, it follows that each ton of iron, in addition to actually absorbing 80 pounds of carbon, will absorb the heat produced by the combustion of another 42 pounds, and radiate this to waste in the pig bed, or it will be lost in the operation of the steel converter. Thus in all some 120 pounds of fuel disappear out of each 25 or 30 hundredweight consumed. This amounts to about one-fifth of one per cent. Even if we add the heat going away in the slag bogey, the amount will not exceed about half of one per cent. What then becomes of the remainder? Some of it is utilised in producing the hot blast which has enabled blast furnaces to turn out a larger yield with a corresponding reduction in the quality of the product, and some is utilised for working the air blast, raising steam in boilers. The bulk is lost, however. This loss it is proposed by Mr. Thwaites to utilise in producing power. Long distance power transmission is a favourite idea of Mr. Thwaites for conveying the energy locked up in the coal fields to the towns and cities far and near.

Here are a couple of comparative analyses of the gases from four typical gas-producer plants, and from four typical blast furnaces.

	Four-Blast Furnaces.	Producer Gas.
Oxygen	0·40	0·00
Nitrogen	53 60	61·10
Carbon dioxide ...	14·44	6·49
„ monoxide ...	30 76	27·61
Hydrogen	0·50	3·59
Marsh gas	0·80	1·21
	100 00	100·00

The blast furnace is thus seen to be a very excellent gas producer. It has indeed all the requisites of a good producer, and particularly that of great height. It is, in fact, quite an ideal producer. It is computed that from a furnace producing 300 tons of pig iron per week, an amount of gas is given off that will yield 1,700 H.P. all the time the furnace is at work, or 1,700 × 168 H.P. hours weekly. Given the means of using the gas in gas engines, the necessary air blast to work the furnace could be produced more cheaply by gas than by steam, and though the use of the hot blast might be continued, there would not be the same obligation of economy to use a hot blast if a better means of utilising the furnace gases were at hand. Hot blast is employed, simply because of its economy, not because hot blast pig is a particularly desirable product. There are still a few cold blast furnaces employed to produce special pig, which is sold at a high price. If furnaces reverted to cold blast and sold the heat in the form of gas, they could afford to make less iron per ton of fuel, and would be glad to do so if it paid better to sell gas than to sell hot blast iron. Given then an outlet for gas, the pig iron might even become a bye product, much as illuminating gas is said to be in a gasworks that has a good sale for its ammonia and coke and other substances, once themselves bye products. The picture is, perhaps, overdrawn, but the idea is perfectly sound. Either the iron or the gas is of primary importance. Assuming that it is still the iron, then may the gas be disposed of at a low figure, and converted by gas engines into electric current. This is a very different scheme from that of using bought coal and turning it into gas in special producers. Already we have got the producers. Their owners are at their wits' ends to make them pay. They are in easy reach of all the large cities, and, given that London must have energy supplied to it, is there any serious objection to the shipment of coal to some Sussex port, and the rehabilitation of the old Sussex iron industry which ceased, not for want of iron ore, but for lack of charcoal as fuel. Such a scheme of power transmission holds out a hope for the English iron industry in which it may be said that of America can hardly share. American distances are so very much greater than those of England, that the English blast furnaces could reap a benefit where those of America would be too far removed from large cities to do so. A 300 ton per week blast furnace develops sufficient power in the form of spare producer gas to provide electric current to drive a full sized modern cotton mill all day, and to keep alight 75,000 incandescent lamps the remaining portion of the 24 hours. Now, all the blast furnaces in Britain at the maximum yield of nine million tons annually would scarcely provide power sufficient for the single requirements of the cotton industry alone, from which it follows that there is no real need to leave a single furnace on the existing wasteful system. The gases from the blast furnace escape at about 740° of temperature Fahr. They are, therefore, available by reason of this temperature for producing a very considerable heat in a regenerative stove without being made to burn. Thus, the hot blast can be still used as a means for cooling the gases on their way to the holders before use, and it is said that the greatest fuel saving in the blast furnace is in the earlier acquisitions of heat by the blast rather than in the higher ranges. Hot blast at present is produced not by the cooling of the gases by passing them through regenerators, but by actually burning the gases with fresh air in the stoves. Mr. Thwaites computes that for every ton of hot blast iron there are surplus gases, after providing for both the present hot blast and the power to produce it, equivalent to 8·555 cwts. of carbon fuel, while in cold blast furnaces the surplus gas is equal to 25 cwts. per ton of pig produced. From these figures it is he deduces the power of a 300-ton furnace as 1,710 H.P., and for the 300-ton cold blast furnace 2,496 H.P. Now, if we take Mr. Thwaites's figures to be correct and remember that blast furnace gases are practically the same in composition as "producer" gas, we have before us the proposition that the blast furnace is to be regarded simply as a huge gas producer; that its primary product is gas which is to be cooled in the hot blast stove, and then washed and stored and used in gas engines; first, to work the blowing engines of the furnace, and then to work electric generators for the purpose of producing electricity for transmission to the populous centres. The production of pig-iron, so variable as it is known to be, may, or may not, be

carried on. If iron be needed it can be made as a bye product, and it can be made either of the hot or the cold blast variety without any consideration being given to the economy of fuel so long as the demand for gas is greater than the supply, as it would eventually become should this idea of generating power at the coal fields become crystallised into practice. The prospect is an alluring one for the iron manufacturer, for it implies the smelting of iron with next to no fuel beyond that necessary to supply blast, balance radiation, and liquefy the iron and slag and find the graphite of the pig. Only such heat is really expended as serves to raise the temperature of the iron and slag to the running point, and to become latent in doing this and dissociating the flux, &c. For economy's sake the index of the furnace or the ratio $\frac{CO_2}{CO}$ need not be considered, except that for gas producing purposes it is best as small as possible.

Given, then, the practicability of the application of the system to the blast furnace, and this is about to be tested, it would appear that the system of electrical transmission of energy would receive an immense impetus. The fuel would be practically a gift, or divided between the distribution company and the iron manufacturer, and the present endeavours to render the blast furnace economical in fuel, and which are often productive of a pig very poor in carbon and useless for many purposes of the founder, may be discontinued, for there is no need to economise fuel where the gas supply is unequal to the demand for it.

One reason why the blast furnace may be looked upon as so ideal a producer of gas, lies in the fact that there is no clinker to be removed and no ashes. The blast furnace has three products only, viz., gas, iron, and slag. The two latter are run out of the furnace by their own liquidity, the iron going to the pig bed or Bessemer converter, and the slag to the waste heap, or to be cast into slag blocks or bricks, or blown by steam into slag wool. The reason why the supply of gas is not perceived to be even so great as it really is from a furnace is because it is used under steam boilers to raise steam. Now the worst use for carbonic oxide gas is to burn it under boilers. It has a blue transparent non-radiant flame, and the efficiency is very low. An enormous saving of gas would be made by using gas engines to actuate the air blast, saving the gas now unconsumed for power purposes outside the iron works, as above, in producing electrical energy.

As a test of the practicability of using blast furnace gas in a gas engine, it may be stated that a gas has been synthesised containing only 16 per cent. of CO (carbonic oxide), and as much as 14 per cent. of carbon dioxide (CO_2), and, tried in a gas engine, there was no miss fire in a run of 12 hours. With so poor a gas there should be no difficulty with the normal product of the blast furnace, especially when it is realised that there need be no attempt made to produce any CO_2; the index of the furnace being no longer of importance as an economy in iron production. Given, then, the success of this idea, the problem of long distance transmission of power would be immensely simplified. There would no longer be any room to argue the case as between cost of production and loss of transmission and the carriage of energy in the solid, for here we have flowing away to waste a very Niagara of energy in combustible gas of the quality that the best producers aim at turning out, and such as is now being used in some of the largest gas engines hitherto made, both in this country and in France. The question narrows itself down to an estimate of the cost of wayleaves and line, the chief cost of the latter being the conductor, which, non-wasting, and of permanent value, would form a very stable asset as a security for low interest-bearing bonds. The present necessity for blowing out a furnace in times of bad trade in iron would case, with great advantage to the durability of the furnace. Given, then, the possibility of the gas being thus utilised, the success of the scheme awaits only gas engines of large powers being put on the market as a regular production.

The Lighting of Liverpool.—We understand that the negotiations for the purchase of the undertaking of the Liverpool Electric Supply Company by the Corporation are still pending.

LAW RELATIVE TO CONDUCTORS OF ELECTRIC ENERGY IN FRANCE.

In the sitting of the Chamber of Deputies of November 20th, 1894, a Bill was discussed relating to electric conductors other than telegraphic and telephonic, the substance of which, as given by *L'Energie Electrique*, was as follows :—

Art. 1.—Outside the public roads, electric conductors, which are not intended for the transmission of signals or messages, and to which the decree of December 27th, 1851, does not apply, may be erected without authorisation or declaration.

Art. 2.—Aerial conductors shall not be erected within a zone of 10 metres in horizontal projection on either side of a telegraphic or telephonic line without the previous consent of the administration of Posts and Telegraphs.

Consequently, every erection of conductors under the conditions of the preceding paragraph ought to be made the object of a declaration previously addressed to the prefect of the department, or to the prefect of the police in the district. This declaration will be registered according to its date, and a receipt given. It will be communicated without delay to the chief of the local service of the Posts and Telegraphs, and transmitted by them to the central administration.

The department of Posts and Telegraphs shall give notice within three months of the declaration, of the acceptance of the scheme, or of the modifications which are required.

In case of non-agreement, the aerial conductors will be established in conformity with the decision of the Minister of Commerce of Industry of Posts and Telegraphs, and after taking the opinion of a Board of Electricity as laid down by the *Article* 6 below.

In case of urgency, and especially in case of a temporary installation, the delay of three months contemplated in the third paragraph of the present article shall be abridged.

Art. 3.—The Minister, with the advice of the Board of Electricity, determines the modifications to be made to guarantee the lines whose conductors already exist inside the above zone, having regard also to rights which may be acquired. The Department of Posts and Telegraphs shall advise within six months at the most, from the promulgation of the present law, the parties whose conductors must be modified. Those who make use of those conductors are required to conform to the ministerial prescriptions within at least one year from the order by the Department of Posts and Telegraphs.

Art. 4.—No conductor shall be established above or below the public roads without authorisation given by the prefect upon the technical advice of the engineers of the Posts and Telegraphs, and conformably to the instructions of the Minister of Commerce of Industry and of Telegraphs.

Art. 5.—The above dispositions do not apply to installations of conductors of electric energy made by the administrations of the State for their own use, or by undertakings of the public service subject to the control of the administration.

The plans for these electric installations, as well as all the modifications which will be made in them, ought, except when they concern railways or waterways to be submitted to the approbation of the Minister of Posts and Telegraphs, after examination and conference with the services interested.

Art 6.—There shall be formed by the Minister of Commerce of Industry of Posts and Telegraphs, a permanent Board of Electricity, composed half of professional representatives of the great electric industries of France, or of the industries making use of the applications of electricity. The members of the board and its president will be nominated by the minister. The president will be chosen outside the members of the board.

The Board of Electricity shall give its opinion upon the general rules in the cases had in view in the *Articles* 4 and 5 above, and upon all questions submitted to them by the minister.

Art. 7.—Every electric installation shall be used and maintained in such a manner as not to disturb, by induction, derivation, or otherwise, telegraphic or telephonic transmission on pre-existing lines.

When the installation shall require, for this purpose, the displacement or modification of pre-existing telegraphic or telephonic lines, the Board of Electricity shall consult con-

formably to the articles 2, 3 and 6 above. The expenses necessitated by these displacements or modifications will be paid by the user.

Art. 8.—Relates to penalties for the infringement of the law.

Article 9.—The decree of May 15th, 1888, is abrogated.

CORRESPONDENCE.

Private and Public Supply.

I gather from your issue that a saving of £505 has been effected in about six months at one of the large southern hotels by taking the supply for lighting from the Corporation mains, in preference to taking it from their own private plant. Having had a good deal of experience in hotel lighting, both as regards the systems of wiring and also the putting down and running of hotel lighting plant, I should like (with your permission) to ask a few questions as to how the said amount can be saved about six months by taking such a course. I quite understand that the majority of small private installations, with their own generating plants, are run quite reckless as regards economy, but do not think it is right to say it is a fair saving to place such installations on a well-managed supply company's mains, and, perhaps, change the majority of 16 and 25 into 8 candle-power lamps, and to use the utmost care in seeing that every lamp not needed was turned out. I quite agree that it is the right thing to do (but do it in both cases). The question is, did the same number of B.T. units pass through the supply company's meter as used to be generated by their own plant in the same length of time?

In my experience, I have found that in most private installations (with their own generating plants) that there is a tendency to burn as many lamps as possible, simply for effect, and sometimes (by the system of wiring) in waste, which, of course, means unnecessary coal, water, wear, &c. But when run through a supply company's meter, there seems to be more attention paid to the waste of current by leaving lamps alight when not wanted for illumination. I have found that by paying strict attention to this it has brought the expenses of coal and water, &c., down a good deal, and in the case of installations of, say, from 1,000 16-candle-power lamps upwards (with their own fairly economical steam plants), that they can be made to pay, and to compete well, against the taking of current from supply companies' mains (and allowing a fair amount for depreciation); being interested in this subject, I should like to hear of other engineers' experiences as regards the cost of running some of the large *private* plants to be found in the southern counties, where the price of coal generally runs about the same.

William Durtnall,
Chief Engineer Cannon Street Hotel Electric Light Department.

March 6th, 1895.

Electric Refrigerator.

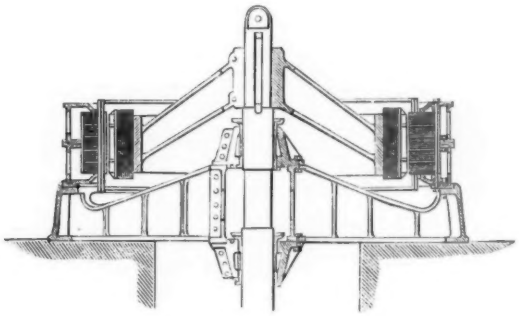
Your correspondent, "Doubtful Thomas," in the Review for March 8th, asks if there has ever been issued a patent for a refrigerator involving the Peltier effect. If I am not mistaken, the United States Patent Office gravely issued a patent to Mr. Mark Dewey for such a refrigerator some time in 1888 or 1889—I believe in 1889. The number of the patent (U.S.) would therefore lie between 300,000 and 400,000, and will be found, most likely, in the beginning of the 400,000 specification numbers. About that time Mr. Dewey was a prolific creator of a series of wonderful and terrible letters patent subjects—a parallel to the Peltier effect refrigerator being a scheme for the utilisation of lightning strokes for storing energy! Imagine the excitement of the caretaker of the condensers, after a week's newspaper reading in undisturbed seclusion, when an input of 10 million potential horse-power would occur suddenly. He might well then seek the Peltier effect refrigerator.

James Mark Barr.

Central Technical College.

Niagara Dynamos.

From the issues of the Electrical Review of February 15th, 22nd, and March 1st, I notice that the old controversy respecting the Niagara alternators is cropping up again. As in this connection my name appears in each one of the above-mentioned publications, and as attention has before now been drawn by other engineers to the similarity which exists between my dynamos and those to be erected at Niagara, I think it will be well to cut short any further discussion by publishing here the design I submitted to the Niagara Construction Corporation on September 20th, 1892. The illustration represents a 5,000-H.P. two-phase generator of my design.



With regard to this type of machine, my claims of priority are as follows:—

1. A design in which the employment of a vertical generator shaft, which is a prolongation of the turbine shaft, is rendered practicable.

2. The "umbrella shape" form of the field magnet system. This design obviates the necessity for a bearing above the field magnets, by bringing down the poles with their exciting coils into the same horizontal plane, with a bearing placed just above the floor line.

3. The mode of winding the field coils with flat copper strip edge-on, so that the insulation cannot be crushed or otherwise damaged by the excessive centrifugal forces which, in this instance, will be exerted on the winding.

4. The method of armature winding. In the scheme submitted I proposed that rectangular copper bars should be buried in slots in the armature, two in each slot; that the insulation should be mica; that the whole winding, including the end projections and connections, should lie on a cylindric surface. This latter arrangement facilitates removal in case of repair, reduces the number of bends, and likewise the number of joints to be soldered or otherwise connected, thus rendering more perfect insulation possible.

In addition to the above, there are several minor points which it is not necessary to discuss here.

It is quite true that Prof. Forbes has seen no machine of mine with an exterior rotating field magnet system, but I may in passing mention that, while developing the scheme I submitted, I had this arrangement in view (although I, at that time, in no way considered it a novel feature of design; for example, the same device will be found described and illustrated as employed by Patin in *L'Industrie Electrique* for May 25th, 1892), but its adoption for the case in question seemed to me unwise, for reasons already pointed out in the discussion of Forbes's paper, read before the Institution of Electrical Engineers.

A comparison of the illustrations in the *Electrical Engineer* of New York, January 16th, 1895, with the drawing I publish here, will establish the fact that certainly the first two points for which I claim priority have been introduced into the design of the Niagara alternators. Regarding the third point, the description is not sufficiently minute to say definitely, and as for the fourth, that too is indefinite. Allow me to point out that figs. 2 and 4 do not agree with each other. In fig. 2, V-shaped connections are shown, while fig. 4 leads one to suppose that my method of end connections has been adopted.

C. E. L. Brown.

Baden, *March 5th*, 1895.

I have just returned from Niagara and Pittsburg, and offer one or two conundrums for your consideration:—

A designs a dynamo, with revolving armature, when B,

the designer of the turbines, says, "You have forgotten the fly-wheel."

A then puts a fly-wheel on the armature shaft and submits the design to C. C says, "Yes, that is very nice; but why don't you revolve the field magnets and do away with the fly-wheel?"

Question 1.—Is that dynamo the design of A or C?

Question 2.—When the dynamo gets to work, does A desire to take the responsibility for the speed and governing arrangements, or does C?

There is no prize for the solutions, and I propound these conundrums to you for what they are worth.

H. W. Handcock.

March 11*th*, 1895.

May we ask space in your "Correspondence" columns for a little friendly criticism, for the benefit of your readers generally, upon a very bold editorial expression on your part in the Electrical Review of March 8th, where you state that with regard to a new arrangement in dynamos of a revolving magnet outside an armature instead of inside, "practically and scientifically there can be no invention in that."

Surely it is a rash statement for any one to make, even when clothed in the mystic editorial "we," and especially in a scientific journal that should at least preserve an "open mind," that any rearrangement of parts in any apparatus, if they have the slightest utility or even cheapness of construction to recommend them, is not practically and scientifically an invention, when we have such well known legal dicta as the following, on doubtful subject matter for patent claims.

Sir W. C. Tindal, C.J., in Crane *v.* Price, states:—"If the result produced by such a combination is either a new article, a better article, or a cheaper article to the public than that produced before by the old method, such combination is an invention."

Lord Justice Bramwell states in Hayward *v.* Hamilton:—"He has found out something. He has made an article that was not made before. . . . . One cannot help making this remark that it is very strange, if it is no invention, that it has never been done before. Why has it never been done before? Because nobody else found it out, which I take to be equivalent to invention."

Though the scientific mind is apt to require considerable departure from known methods to warrant so honourable a title as "an invention," we submit that the claims of even trivial rearrangements of parts (if productive of useful results) to the same honourable title of invention must not be ignored.

Fell & Wilding.

March 11*th*, 1895.

Cause of the St. Pancras Explosions.

In passing along the Euston Road this morning I noticed men at work brushing out the trench in which the St. Pancras electric mains were laid. The bare conductors were passed through an earthenware block, which appeared to me to have the ordinary salt glaze generally used upon a great deal of pottery ware. With the condensed moisture on these blocks, which must always be present in such trenches, and the bare copper strips conveying current resting upon the glaze, we have the conditions of electrolysis, and I believe the current is a direct one. If my assumption is correct, this explains where the salt comes from which yields the sodium, and in that case it may be found safe to use such glazed earthenware blocks with an alternating current, although highly dangerous with direct currents.

J. Sinclair Fairfax.

The Compiling of Catalogues.

I note Messrs. Elliott Brothers' letter in your last issue. They make no reference to their imitation of my patented apparatus, additional proof of which I have before me, in the form of a signed quotation for same.

They, however, make an unfair and futile effort at a *tu quoque* reply, and taking one of several pamphlets issued by me, entitled "The Ayrton-Mather Galvanometer and its Accessories," they claim my woodcuts (figs. 5 and 6) as *their* original designs, without mentioning that these represent an ordinary wooden scale-stand and shunt-box. These, as they naïvely admit, have been well known for 25 years. Indeed, they have been manufactured by all makers of testing instruments.

Though Messrs. Elliott Brothers were informed on the 4th inst. that my list No. 2, of 1892, being out of print, could not be sent them, their letter is so worded, as to create the impression that they are criticising my general list. I told them I hoped shortly to forward them copy of my new catalogue, for which some 60 or 70 original woodcuts have been prepared, chiefly of instruments designed or perfected during the last few years.

I can assure you I have the greatest horror of flattering them, as they suggest, by any imitation of their methods.

Robt. W. Paul.

[We cannot insert any further correspondence on this subject.—Eds. Elec. Rev.]

Re Small Inside Reflectors for Alternating Current Arc Lamps.

In No. 900 of your valuable paper there is a reply from the manufacturers of the "Helios" lamp which requires an immediate answer on our part, and we should esteem it a favour if you would kindly insert the following:—

In the first place we, the same as the firm of "Helios," do not consider your paper the proper place in which to settle patent disputes, and have never contended this; on the contrary, we desire now to see the threatened proceedings taken, so that the matter may be brought to a definite issue.

Nothing is farther from our intention than to draw back, for we shall still supply and make these small reflectors in a quality of enamel which, in spite of the mis-statements in the letter of the firm above referred to, is not behind even that of the "Helios" make.

The accusation made against us that we wish to save ourselves the expense of making and constructing new plans, &c., is quite groundless, as is proved by the existence in our works of a large construction and drawing office, and also a laboratory for testing lamps, and by the considerable number of patents already taken out by us.

Claim No. 2 of a patent of "Cörpershen" is mentioned by this firm as substantiating their position; but this is quite as weak as the claim No. 7, and does not touch us at all; on the contrary, it enables us to point to the firm of "Helios" as imitating.

In cases of patent disputes, of course personal opinion or estimation has not to be considered at all, but the matter simply rests on exactly what is said in the claim of the patent, and if the matter of it at the time of its registration is quite new, and this decision we should be quite pleased to leave to an English law court, based upon the materials and facts at our disposal. This our last and final explanation.

Thanking you for inserting this letter in your valuable paper and apologising for trespassing on your space again,

Koerting & Mathieson.

Arc Lamp Works, Leutzsch, Leipzig,
March 13*th*, 1895.

The Crocker-Wheeler Motor.

Our attention has been directed to a remark of your reviewer on Sir David Salomons's book. You mention, as a reason for the illustration of the Crocker-Wheeler motor in that book, that this motor is rarely used. No doubt Sir David Salomons was better aware than your reviewer of the fact that, at the present time, there are considerably more than 500 of these motors in use in this country.

The General Electric Company, Limited.
H. Hirst, *Director.*

Re Cardiff Lighting.

Need I say that I had nothing to do with the regulations you alluded to in the Electrical Review of the 8th inst.

Wm. H. Massey.

March 12*th*, 1895.

[We refer to this subject in a note.—Eds. Elec. Rev.]

Errata.—In Mr. Barber Starkey's letter on "Windmills for Electrical Experiments," published last week, in the ninth line the word *arm* is used where it ought to be *sail*, and in the last line but one the word *nut* is used where it ought to be *hub*.—Eds. Elec. Rev.

ELECTRIFICATION OF AIR AND OTHER GASES BY BUBBLING THROUGH WATER AND OTHER LIQUIDS.*

By Lord KELVIN, P.R.S., MAGNUS MACLEAN, M.A., F.R.S.E., and ALEXANDER GALT, B.Sc., F.R.S.E.

Section 1.—At the meeting of the British Association in Oxford in August, 1894, a communication was given to Section A, entitled "Preliminary Experiments to find if Subtraction of Water from Air Electrifies it." These experiments were performed during July of 1894, and were a continuation of experiments which were commenced in the Physical Laboratory of the University of Glasgow in December of 1868 with the same object, but which were then, for various reasons, discontinued before any decisive result had been obtained.

Section 2.—A glass U-tube with vertical branches (fig. 1), each

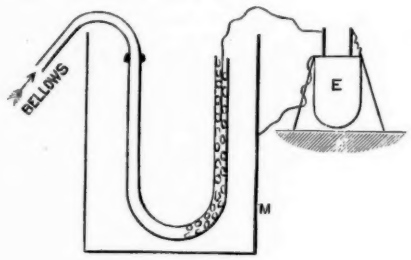


Fig. 1.

18 inches long and about 1 inch bore, with the upper 8 inches of one of the branches carefully coated outside and inside with clean shellac varnish, was held fixed by an uninsulated support attached to the upper end of this branch. The other branch was filled with little fragments of pumice soaked in strong sulphuric acid or in water, and a fine platinum wire, with one end touching the pumice, connected it to the insulated electrode of a quadrant electrometer. A metal can, M, large enough to surround both branches of the U-tube without touching either, was placed so as to guard the tube from electric influences of surrounding bodies, the most disturbing of which is liable to be the woollen cloth sleeves of the experimenters or observers moving in the neighbourhood. This metal can was kept in metallic connection with the outside metal case of the quadrant electrometer. The length of the exposed platinum wire between the U-tube and the electrometer was so short that it did not need a metal screen to guard it against irregular influences. An India-rubber tube from an ordinary blowpipe bellows was connected to the uninsulated end of the U-tube. Air was blown through it steadily for nearly an hour. With the pumice soaked in strong sulphuric acid in the other branch, the electrometer reading rose in the course of three-quarters of an hour to about 9 volts positive. *When the pumice was moistened with water, instead of sulphuric acid, no such effect was observed.* The result of the first experiment proves decisively that the passage of the air through the U-tube gave positive electricity to the sulphuric acid, and therefore sent away the dried air with negative electricity. A corresponding experiment with fragments of pure chloride of calcium instead of pumice in sulphuric acid, gave a similar result. In repetition of the experiments, however, it was noticed that the strong positive electrification of the U-tube seemed to commence somewhat suddenly when a gurgling sound—due to the bubbling of air through free liquid, whether sulphuric acid or chloride of calcium solution in the bend of the U-tube—began to be heard. It has since been ascertained that it was because no liquid accumulated in the bottom of the U-tube that no electric effect was found when the pumice was moistened with pure water.

Section 3.—Arrangements were made to prevent any bubbling of the air through liquid, by using a straight tube instead of a U-tube. In a large number of experiments with pumice, moistened with pure sulphuric acid in the straight tube, and air blown through for about half an hour, no definite electrification was obtained. In this straight tube, as formerly with the U-tube, pumice moistened with pure water gave no electrification. Chloride of calcium in lumps, not specially dried, gave no effect in the straight tube, but if previously heated to 180° or 200° and put into the straight tube when still hot, it gave an enormous positive electrification immediately on the commencement of blowing. Strong positive electrification was obtained a second time by discharging the electrometer to zero, re-insulating, and re-commencing the blowing. But after discharging a second time, re-insulating, and re-commencing the blowing, no further electrification was found.

Section 4.—In continuation of these experiments on September 25th, the arrangement represented in fig. 2 was set up. The outer metallic guard-vessel, M, was kept connected by a wire to the case, and one pair of quadrants of a quadrant electrometer, E. The water in the inner glass jar, A, was connected by a platinum wire to the other pair of quadrants of the electrometer. To have this inner jar well insulated, it was supported on a block of paraffin, and the other end of the glass tube dipping into the water was fitted into one end of a tube of paraffin, to the other end of which was fitted a tube for ingress of air, from bellows, as shown in the figure. The insulation

* Received February 7th and February 15th, 1895.

of this arrangement was found to be good. When air was blown through the water, it was found that the jar containing the water became positively electrified.

Section 5.—To prevent splashing of water out of the jar, a paper cover was put on its mouth, or the jar was tilted, as shown in fig. 3,

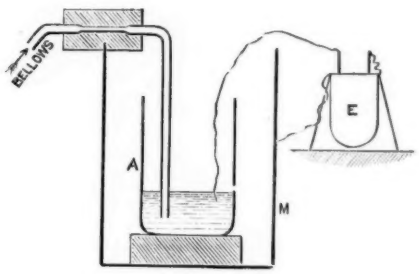


Fig. 2.

so that the bubbles broke against the inside of the jar. In three experiments thus made the same electrification was still found, amounting to about 6 volts positive in a quarter of an hour.

Section 6.—As the jar was in every experiment positively electrified, the air, if unelectrified* when entering it, must have been negatively electrified when leaving it.

Section 7.—To test if the air was negatively electrified after bubbling, on October 11th the apparatus† shown in fig. 4 was set up.

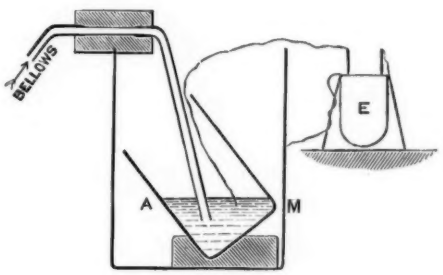


Fig. 3.

The apparatus consists of a large sheet-iron vat, V, V, 123 cm. in diameter, and 70 cm. in height, inverted on a large wooden tray, lined with lead, and supported by three blocks of wood. By filling the tray with water, the air is confined in the vat.

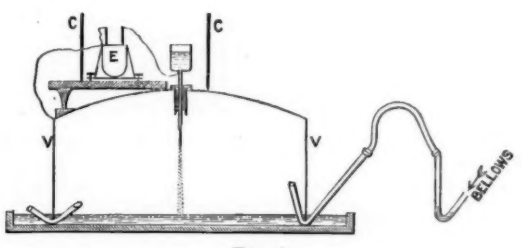


Fig. 4.

C, C, is a metal screen kept metallically connected with the case of the electrometer and with the vat. It surrounds both the electrometer and the water dropper, to prevent any external varying electrifications from vitiating the proper results of our experiments.

This screening of the electrometer is absolutely necessary when it is used with high sensibility (70 scale divisions per volt in our experiments) in a laboratory or other place where various other electric experiments may simultaneously be going on. Four years ago the electrometer, the vat, and the water-dropper, were set up on the class-room table *without a metal screen.* When the deflection indicated about 4 volts negative (see Section 8), the negative lead of Lord Kelvin's house electric-light circuit, which passes through the class-room, was joined to earth. This changed the deflection of the electrometer suddenly by 1 volt in the positive direction. When the positive lead was "earthed," the deflection was changed suddenly by 6 volts in the negative direction. Putting on sixteen 8 C.P. electric lamps, eight on each side of the class-room, changed the deflection by two-thirds of a volt in the negative direction.

* Air was similarly blown from bellows into the vat (see Section 7) without any bubbling, and no electrification was observed.

† The vat, the water dropper, and the electrometer are the same as in the apparatus described in the *Proceedings* of the Royal Society, Vol lvi., year 1894, "Electrification of Air," by Lord Kelvin and Magnus Maclean.

Section 8.—In experimenting with the same apparatus* in 1890 it was found that the water jet electrified the ordinary air of the laboratory negatively, and the present experiments fully confirm this result, showing a gradual negative electrification of the enclosed mass of air rising to about 5 volts in an hour, once every day for the first few days. For twenty-eight days after the vat was set up in October, 1894, fifteen observations of an hour each were taken to find the effect of the water-dropper, with no other disturbing influence on the unchanged volume of air inside the vat. These experiments verify the conclusion (*Phil. Mag.*, August, 1890) that the more the air inside the vat became free of dust, the less became the rate at which the air was negatively electrified by the water-dropper.

Section 9.—On October 15th the vat was lifted from the tray to remove some obstruction in the nozzle of the water-dropper, which was not then flowing freely. Curve (6) was obtained that afternoon. The air in the vat was the ordinary air of the laboratory, and the curve shows the effect of the water-dropper alone in electrifying the air negatively. For the next two days the water-dropper was kept running continuously for about eight hours each day, to wash the dust out of the air, and on the 18th curve (7) was obtained. It

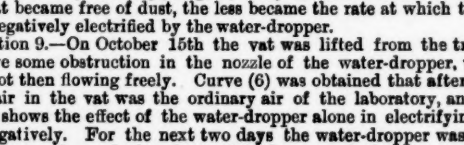


Fig. 5.

shows a much less rate of negative electrification than curve (6). In the experiments of summer 1890 an aspirator was used to draw the air from the vat, and a tube full of cotton-wool was used to filter the air drawn into the vat.

Curves (1) to (5) are reproduced from the 'Philosophical Magazine,' and they show that the more the air becomes free from dust the less is the rate at which the water-dropper electrifies. Thus curve (1) was obtained from the ordinary air of the room in the vat, and curve (2) after the aspirator was working for some time. In this curve the water-dropper itself was running for some time before the first observation was taken. The other curves were obtained after further continuous working of the aspirator.

After curve (4) was obtained the aspirator was worked continuously for twenty-five hours, and then curve (5) was obtained.

(*To be continued.*)

LEGAL.

Attorney-General *v.* St. James's and Pall Mall Electric Light Company, Limited.

On Tuesday last Mr. Justice Kekewich sat in the Chancery Division of the High Court of Justice to hear this action, brought on the motion of the Vestry of St. James's, Westminster, to restrain an alleged nuisance arising from smoke, smell, ashes and vibration.

Mr. Warmington, Q.C., with him Mr. MacMorran (instructed by Messrs. Caprons, Dalton, Hitchings & Brabant, solicitors, of Savile Place) were counsel for the plaintiffs, and the defendants were represented by Sir R. Webster, Q.C., Mr. Fletcher Moulton, Q.C., and Lord Robert Cecil (instructed by Mr. Sidney Morse, of Fenchurch Avenue).

In opening the plaintiff's case, Mr. Warmington said perhaps he could not better describe the defendants' works than by a statement they themselves issued in 1891, giving a ground plan and details of the position of the boilers and shaft they used; and beyond a few words explanatory of the general position, basing the plaintiff's case on the proposition that a nuisance had been created by the defendants. Their central station was in Mason's Yard, which, prior to the erection of the defendants' works, was used as a mews, the stables being in the centre, with a roadway round them. Defendants, for the purposes of their station, both covered what were the mews, and constructed some other works at a considerable depth underneath what was the roadway; these works, in consequence of the small space, necessarily being very crowded. A great many of the witnesses he should call were residents in Duke Street, who would speak to their experiences in the matter since plaintiffs began their operations in the latter end of 1890 and had continued them till the present time. But at the end of 1893 they started another station in Carnegie Street, and that, no doubt, had relieved the Duke Street works. The vibration was certainly not now so serious, but with regard to smoke, smell, and particularly dust and ashes, the state of things was very, very serious. Defendants had pleaded, first, that there was no nuisance; secondly, that if there was a nuisance, it had been remedied; thirdly, that they are a public body acting under a provisional order, and having done under it what it was their duty to do, they were justified——

His Lordship asked did the provisional order differ from that granted to the City of London and other companies?

Both Mr. Warmington and Sir R. Webster simultaneously said no; and Mr. Warmington proceeded to point out that these proceedings were taken under sections 13 and 21 of the Public Health (London) Act of 1891, the provisions of which he read, and added that between November, 1891, and May, 1894, there was an active correspondence between the parties, mainly of this character:—The inhabitants of the district had written to the vestry complaining of the nuisance caused by the works, and these complaints having been investigated by the Sanitary Committee, the vestry clerk was instructed to forward—and accordingly he did forward—copies of these complaints to the defendants, who, from time to time, had made excuses, which in the end came to this—that they would try by new works, improvements and amendments, to abate the nuisance. The reason why he emphasised this correspondence was not so much with the view of occupying his Lordship's time with it, as to point out that defendants alleged that plaintiffs had been guilty of delay; but if it should be necessary, the correspondence could be given to negative that view. He then proposed to call Major Creswell, a resident of Duke Street, to prove the nuisance. On the Major entering the witness box,

Sir R. Webster said it might be convenient, and save time, if at this stage he pointed out that, as far as the Vestry was concerned, neither the Attorney-General nor the public authority had a right to raise this as a question of nuisance. But, beyond that, proceedings had been taken by the Wyndham Club in this matter before Mr. Justice North and Lord (then Sir Horace) Davey appeared for the present defendants. The result was, that on June 27th, 1893, an order was made staying the proceedings on defendants undertaking that if, in the opinion of an engineer to be named by the Board of Trade, or agreed upon between the parties, the works and machinery in Mason's Yard were causing a nuisance, they would take all such reasonable and necessary precautions to secure a remedy as should be recommended. I am perfectly willing (said Sir R. Webster) to give my learned friend the same order in this case, and I believe it will prove perfectly effective as a protection. Sir Douglas Galton has been appointed as the engineer, and he is watching us, and can at any time come down upon us, though as yet he has made no complaint. As it is a public body which is taking these proceedings, I venture to suggest that I should like my offer to be considered before we go into what may prove an expensive and troublesome inquiry. Our case is that between 1892 and 1893 we wished to stop, and did to a great extent stop what was complained of; and I believe since 1894 there has been no just cause of complaint. That is why I think an order might be made on the same lines as in the former case.

Mr. Warmington said this was the first time the plaintiffs had heard anything of this offer, and asked for a short time to consider it, before which he should like to know—

Sir R. Webster said it would, of course, be extended to the smoke and other matters of which plaintiffs complained.

On this the counsel and solicitors, with Sir Frederick Bramwell, who was in attendance for the defendants, retired for a short time. On their return into Court,

Mr. Warmington said an order had been agreed to, practically on the same lines as in the other case.

In substance, said Sir R. Webster, it provides for the calling in of an engineer by the Board of Trade, or the parties to inquire into the matter, but only at the request of the vestry. As we are bearing the expense of the engineer, we think it only fair that this provision shall be made, so as to exclude private individuals from taking the initiative. We apprehend that the vestry, being a public body, will act only if they think there is fair ground for their interference on a substantial case.

His Lordship: And the engineer will direct?

Sir R. Webster: Oh! whatever is to be done.

Mr. Warmington having read the text of the order as thus indicated, and showed that it embraced all the points of plaintiffs' complaint,

His Lordship asked was the power of the Court gone; but both Sir Richard and Mr. Warmington said no; either party might apply.

The proceedings then ended, and the Court was at once cleared of apparently a number of witnesses and others interested in the proceedings.

General Electric Power and Traction Company *v.* Roger Dawson, Limited.

In the Queen's Bench Division of the High Court of Justice, on Friday, the 8th inst. and Saturday, the 9th inst., the trial of this action came before Mr. Justice Wright. The plaintiff's claim was for £68 3s. 7d., balance of an account for goods sold and delivered and for work and labour done. The defendants admitted certain items of the claim, and as to the rest said that the dynamo which they contracted to purchase from the defendants was not up to the contract, and they lost on account of its deficient qualities. The defendants counterclaimed for £38 12s. The defence to the counterclaim was that the dynamo was equal to the requirements stated in the contract, and that the defendants worked it beyond its proper capacity. It appeared from the evidence that the dynamo was supplied and fixed up in the house of a Mr. Perkins. After hearing evidence on both sides, His Lordship gave judgment for the plaintiffs for £68 3s. 7d., with costs, and also on the counterclaim.

The Western and Brazilian Telegraph Company, Limited *v.* The Brazilian Submarine Telegraph Company, Limited.

In the Chancery Division of the High Court of Justice on Friday, the 8th inst., before Mr. Justice Romer, this was an action to restrain the defendants from reducing the telegraphic rates which had been fixed by what they called the "joint purse agreement." Under subsequent arrangement, the defendants had agreed to pay the plaintiffs £6,000 a year, on the defendants extending their system. The defendants contended that under the altered arrangement the terms of the original

* *Phil. Mag.*, August, 1890, "Electrification of Air by a Water Jet," by Maclean and Goto.

agreement were varied so as to enable them to make a reduction in rates without special agreement with the plaintiffs, or under arbitration, as provided by the original agreement.

Mr. Justice Romer held that there was no power to reduce the rates, and made a declaration to that effect, and he required, and obtained from, the defendants an undertaking not to reduce the rates except according to the original agreement.

The Froggatt's Electric Lighting Supply Company, Limited, *v.* Dickson.

In the Chancery Division of the High Court of Justice, on Tuesday, the 12th inst., the trial of this action came before Mr. Justice Romer. The claim was for an injunction to restrain the defendant from interfering with the access by the plaintiff company to a house, No. 25, Warham Street, Kennington, and the yard, warehouse, and other buildings. It appeared that the premises in question were purchased by the plaintiffs for use as workshops, and for the storage of electric accumulators for the supply of the little lights on omnibuses. The substantial question was, whether the defendant had prevented the plaintiffs having proper access to the yard. Soon after the case was opened, it was arranged that there should be no order and no costs in the action.

Bryson *v.* Gordon-Cumming.

Lord Kyllachy, last week at Glasgow, closed the record in an action by William Alexander Bryson, consulting electrical engineer, 11, Bothwell Street, Glasgow, against Sir William Gordon-Cumming, Bart., of Altyre and Gordonstown, Elginshire. Pursuer sued for £115 18s. 5d. In March, 1892, pursuer was consulted by the defender in connection with an installation of electric light at Altyre House. He says it was agreed that pursuer should be allowed a commission at the rate of 4 per cent. on £3,063, the cost of the installation, and the sum sued for represents the balance of an account due. Defender says that pursuer permitted contractors to use inferior material in the putting in of the light, and by his actings otherwise the defender has suffered damage, which he holds pursuer responsible for. He alleges neglect of duty and collusion with the contractors against the pursuer.

Grove *v.* Ford Lloyd Manufacturing Company, Limited.

Mr. Justice Vaughan Williams, sitting as a judge of the Chancery Division, on Wednesday, 13th March, had before him a motion of a receiver in a debenture holders' action which was commenced before the winding up order was made, on the ground that the assets were in danger. The plaintiff held a first mortgage debenture for £1,000, the business of the company being that of electrical engineers. The official receiver is in possession, and the only point was whether in his interest Mr. Jeffries should be appointed in order to sell the plant. The Official Receiver recommended the appointment of Mr. Jeffries, and his lordship acceded to the motion.

BUSINESS NOTICES, &c.

Now Ready.—The Universal Electrical Directory. This directory, which is now on sale at 22, Paternoster Row, by Messrs. H. Alabaster, Gatehouse & Co., contains a total of 20,958 distinct names of individuals and firms, being 2,500 more than were contained in the previous edition, and about 8,000 more than any other electrical directory published. In addition to the incorporation of new names, all have been carefully revised, much financial information has been added, the telegraphic addresses and local telephone numbers are given, and the total of pages in the work is increased by 80, making in all about 866 pages entirely of directory matter. Price 4s.

Alderley Edge.—An attempt made at a recent meeting of the District Council to rescind a previous resolution in favour of obtaining a provisional order, has been defeated.

Ballarat.—The official turning on of the electric light in Ballarat West and Ballarat East took place on February 1st. The plant includes two powerful engines and dynamos of the latest principles. There are erected in the city and town 44 arc lamps, and about 300 incandescents are ready for the private lighting. The present preliminary plant is capable of supplying between 500 and 600 of the smaller lamps. Mr. J. A. Dawson, electrical engineer at the School of Mines, superintended the erection of the plant and mains on behalf of the Ballarat Electric Supply Company, while Mr. H. Harrison acted on behalf of the Crompton Syndicate. Already the orders on hand for the light will, when fulfilled keep the present machinery fully employed.

Bangor.—The Water and Gas Committee have been instructed to report upon the expediency and cost of providing electric lighting for the town before proceeding to expend any large amount on the gas works.

Bath.—Major Cardew conducted an inquiry on behalf of the Board of Trade at the Guildhall on Wednesday, last week, into the application of the Urban Sanitary Authority for a provisional order under the Electric Lighting Acts, to enable them to have the city electric lighting under their own control. It will be remembered that the Electric Lighting Company intimated their intention of applying to the Board of Trade for a provisional order to extend their lighting area, but after a full discussion of the question in Council, and obtaining the advice of an electrical expert, the authority withheld their consent and decided to apply to the Board of Trade for a provisional order themselves. The electrical experts engaged were Sir Frederick Bramwell (for the company), and Mr. Hammond (for the corporation). Mr. T. O. Callender, the chairman of the company, was the first witness examined. He estimated that the sum of £15,000 would be more than sufficient to carry out any extensions that would be required for many years. Several witnesses were called to prove the satisfactory character of the private lighting. Mr. Metzger, the manager of the company, was also examined at considerable length with regard to the works and supply. Sir Frederick Bramwell was next examined. He was satisfied the company would have no difficulty in raising the further capital if the provisional order were granted them. He had no reason to suppose that the Authority would do better than a company. Mr. MacMorran opened the case for the Corporation. He said the company had their licence on the distinct understanding that it was to come to an end at the end of seven years, and they now came to the Board of Trade saying, "We have made a very bad bargain, and you must help us to get out of it." The Corporation were prepared themselves to apply for a provisional order to light the whole city, and contended that it was much better in the public interest and for the public convenience that the light should be under their control. He contended that the company could not afford to supply electricity so cheaply as the Corporation, who could acquire the present works or lay down a station of their own. Alderman Sturges, chairman of the Lighting Committee of the Corporation, was examined at length by Mr. MacMorran. He emphasised the fact that the Authority were anxious to become masters of the situation. It was not only the feeling locally, but throughout the country. Gen. Mainwaring rose at the conclusion of Alderman Sturges's evidence and said he could thoroughly bear out what had been said with regard to the advisability of the Corporation having the sole control of the electric light. The Mayor was strongly of opinion that in the interests of the city the control of the light should be in the hands of the Corporation. A number of other witnesses were called for the Corporation, including Mr. Robert Hammond, who expressed a strong opinion that the lighting of the city should be in the hands of the Authority. The accounts issued by authorities who had taken the lighting up themselves had universally been most favourable. He knew of no case where a local authority had not in its second year of operation made sufficient to cover the sinking fund and interest, and leave a satisfactory margin. Gradually the public lighting would be paid for out of the profits of the private lighting.

Blackpool.—We understand that the Blackpool Tower Company have decided to instal a large battery of accumulators, and that the work has been entrusted to Messrs. B. Verity & Sons, their contractors, at an estimated cost of about £1,500. We believe that chloride accumulators are to be used.

Brighton.—At the last meeting of the Council the electric lighting accounts, to which we referred last week in our "City Notes" columns, were adopted. The salary of Mr. Wright, the engineer, was increased from £400 to £600.

Bristol.—A number of suburban districts are to be canvassed with a view to ascertaining whether there will be a demand for current large enough to warrant the extension of the mains there.

Chelmsford.—King Edward's Avenue is to be lighted by incandescent electric lamps.

Chester.—We understand that the Electric Lighting Committee intend recommending the adoption of the following scheme for Chester, Dr. John Hopkinson being the adviser:—Low tension system from the generating station to the distributing station at Hamilton Place, and the high tension system from that point to the streets in the area to be supplied. This scheme was adopted with a view to facilitating extensions when they become necessary.

The Council, at their meeting this week, were to decide whether to accept tenders submitted for engines, boilers, and dynamos, amounting to £8,518, also to pass a resolution applying for sanction to borrow £25,000 to cover expenditure up to the present time, also the above items and those mentioned in Dr. Hopkinson's estimate, including provision for street lighting within the area to be first dealt with and a sum to meet any further demands for expenditure that may arise later.

Dorchester.—The jewellery and clock establishment of Mr. J. Vincent, in St. Mary Street, has been lighted with 70 16-C.P. lamps. The plant comprises a 4-H.P. gas engine and a Royce dynamo. Messrs. J. H. Royce & Co, of Manchester, carried out the installation.

Dover.—It has been decided to turn on the light for the use of the public on April 8th. All the machinery is now erected and experimental lighting was made last Friday.

Dundee.—Frequent bursts having taken place in the present iron tubes at the electric lighting station, a suggestion was made that brass tubes should be substituted at a cost of £40 10s. The Gas Committee have recommended the Council to agree to the substitution proposed, and to accept the offer of Messrs. Whyte and Cooper for the work.

Eastbourne.—There is to be an agreement drawn up between the electric lighting company and the Council indemnifying the latter against any claim arising from accident caused by their mains and boxes.

Eccles.—The Eccles Corporation have appointed Mr. S. V. Clirehugh their consulting engineer for carrying out an electric lighting scheme. It is understood that an expenditure of about £20,000 is contemplated.

Edinburgh.—Mr. Monkhouse is proceeding rapidly, under Prof. Kennedy, with the electric street lighting of Edinburgh, and the number of arc lamps are to equal those in the City of London. For the use of the trimmers four of Heathman's patent telescopic ladder towers have been ordered, fitted on cycle pattern rubber tired wheels, so that one man can transport each about the streets; and new patent compensating spindles have been devised by Mr. Heathman to adjust and support the side which happens to be over a gutter.

A Committee has to consider and report whether, and if so, what, steps should be taken in the interests of public safety to secure that any faults in the gas mains and service pipes should be detected and removed without delay.

The electric light is to be turned on on April 10th.

Hoole.—The lighting question is to be thoroughly considered by a committee. Great dissatisfaction is expressed at the Gas Company's charges and the quality of the gas. Some of the councillors are favourably disposed towards electric lighting, the chairman considering that £3,500 would cover the cost of a low tension system for the district.

Keswick.—A committee has been appointed to consider the position of the electric light company in relation to the Council.

Lambeth.—At the last Vestry meeting a letter was read from Mr. Sidney Morse, stating that if the Vestry would appoint a committee he would be pleased to submit a proposal to the committee on behalf of the County of London and Brush Provincial Electric Lighting Company, Limited, for transfer to the company of the Lambeth electric lighting order. The Vestry decided that any proposals should be made to the Vestry as a whole.

Leeds.—The New Post Office at Leeds, which is nearly completed, will be one of the most handsome of the provincial post offices. It is to be lighted solely by electricity. The contract for boilers has been placed with Messrs. Babcock and Wilcox. The steam dynamos, three in number, will be supplied by Messrs. J. H. Holmes & Co., the combination being Willans engines of 60 H.P. indicated, driving Holmes dynamos direct. The internal wiring and fittings will be supplied and fixed by Messrs. Lund Bros. & Co. There are to be, in all, 36 Brockie-Pell arc lamps and 563 glow lamps, mostly of 16 C.P. It is anticipated that considerable use will be made of electric motors for lifts, and to work air pumps for the pneumatic transmission of telegraph messages. The whole of the engineering works are being carried out to the specification and under the supervision of Mr. W. H. Preece, C.B. Mr. Preece has selected Mr. R. Gill, late of the electric lighting staff at the G.P.O., London, to be resident clerk of works to supervise the various contracts locally.

Lowestoft.—At the monthly Town Council meeting on Tuesday night it was reported that a refuse utilisation and electric lighting scheme prepared by Mr. T. W. Baker had been considered, but that no decision had been arrived at. The scheme provided for the disposal of 120 tons of refuse weekly by three furnaces. He was of opinion that a plant capable of supplying 2,700 8-C.P. lamps alight at one time or 4 000 wired up, might be soon fully loaded, and that 1,500 lamps would be wired up during the first year, but it would not be until the third year that the plant would be fairly taken up and remunerative. Sevenpence per unit might be the charge for the first year or two, which would give a return of 10s. 6d. per lamp wired up per annum. With regard to street lighting, he recommended 40 arc lamps of 2,000 candle-power each to take the place of the present lamps, which now cost £202 8s. 6d. per annum. He proposed to use those arc lamps until midnight, and then to replace them on the same posts with two 16-C.P. incandescent lamps for the remainder of the night. The estimated cost was £540 per annum. The total cost of the plant would be £10,000. He estimated the difference between expenditure and income for the first year would be a favourable balance of £168; second year, £505; and for the third year, £843. The amount required for interest and redemption of the loan would be £631 15s. 5d. per annum.

Morecambe.—Plans have been approved by the Council for a new generating station for the Electric Lighting Company in Moss Lane.

Nottingham.—St. Thomas's Church, which has just been lighted by electricity, has 95 lights, distributed as follows:—the corona 24, pulpit 1, organ loft and choir gallery 7, altar 5, side aisles 32, standards 14, west end 6, vestry 3. The schoolroom is also lighted electrically.

For some months four arc lamps have lighted the Market Place. Last week the current was turned on to four additional lamps of 2,000 C.P. each, in the same district.

Oswestry.—At the last Council meeting a letter was read from Mr. H. J. Wallace Pugh, secretary to the Oswestry Electric Lighting Company asking for an extension of time in which to make the usual deposit. The application was granted.

Salisbury.—The matter of the provisional order which has been obtained, has been referred to a small committee of the Council.

Southport.—We understand the Corporation contemplate extending their electric light works so as to enable them to light the Promenade and Lord Street, and possibly several other contiguous streets. Prof. A. B. W. Kennedy is the Corporation's adviser. He recommends the erection of 40 lamps in the two thoroughfares mentioned.

Sunderland.—Messrs. Ernest Scott & Mountain, Limited, of Newcastle-on-Tyne, have just completed an electric light installation for the new joiners' shops recently built by Messrs. J. L. Thompson & Sons, North Sands, Sunderland. The plant consists of a Tyne compound-wound dynamo capable of giving an output of 400 ampères at an E.M.F. of 65 volts, when running at a speed of approximately 600 revolutions per minute. At present the dynamo is driven by the existing steam engine which drives the bending rolls and other machinery in the ship repairing yard. The current from the dynamo is taken to a main switchboard and is from there divided into three circuits, one circuit being taken overhead to the joiners' shop, another circuit along the jetty for driving cluster lights for repairing oil ships, &c., and also for working electric deck planers and drilling machines, and the third circuit is provided as a spare, as the firm contemplate applying electricity for many other purposes beyond lighting. In the joiner's shop are 18 arc lamps of 2,000 C.P. each. Five arc lamps are placed on the ground floor and 13 on the first floor. The varnishing shop and light joiner's shop are lighted with incandescent lamps of 16 C.P., there being in all between 40 and 50 lamps. Along each side of the first floor and ground floor a separate circuit is laid with wall plugs about every 10 feet, portable hand lamps being provided so that the shafting or underside of any of the wood working machines can be quickly examined.

Before the Town Council commenced business on 6th inst., current was turned on for the first time to the arc lamps in front of the Town Hall. Part of the interior of the Hall is also lighted by electricity.

Tilbury.—A committee has been appointed by the Parish Council to consider the question of lighting the parish with either gas, electricity, or oil.

Tunbridge Wells.—The question of lighting the Municipal Buildings (including the Town Hall) by electricity is under consideration. It is stated that it will cost £300 to light the Town Hall; and, curiously enough, the Mayor, "speaking from his own experience, suggested that the matter of the Town Hall installation should not be hurried." This is a rather curious attitude for the chairman of the City of London Electric Lighting Company to take.

Wells.—The Town Council have sanctioned a scheme proposed by Mr. A. Dixon Brown, for the public lighting by electricity. We believe the cost is to be £350 per annum.

West Bromwich.—The Piercy Brickworks, belonging to the firm of Joseph Hamblet & Co., have been completely fitted and lighted with electricity. The three-wire system is adopted, the lights used being incandescent 16-candle-power 100-volt lamps. Throughout the works there are 189 lights. A 12-horse nominal gas engine drives two dynamos of the capacity of 100-light and 60-light respectively. The work has been carried out by Messrs. John Watson and Co., of Oldbury.

Wolverhampton.—The following were the payments made in connection with the electric lighting scheme during the December quarter, 1894:—Callender's Company, £621 14s. 5d.; Fletcher, Hirst & Co., £150; J. Thompson, £947; Johnson & Phillips, £300; S. Z. de Ferranti, £100; Public Works' Committee, £110 13s. 6d. Also other items for salaries and wages, &c.

Worcester.—The question of the electric lighting extras, to which we have already referred, was the subject of a very lengthy discussion at the last meeting of the City Council. The question was again referred back to the committee. Mr. Caink, the engineer, has also published in self defence a lengthy statement, explaining in detail the various items upon which the increases occurred. When the electric light bill was presented to the Council the other day, it was shown that for 27 arc lamps the cost was £168 15s. for the quarter ended January 11th, as compared with 60 gas lamps formerly used, which cost only £180. The charge was thought exorbitant by some councillors, and others thinking an error in calculation had occurred, the item was referred back to the committee.

Yarmouth.—At the Town Council meeting on Tuesday, it was reported that the present amount of arc lighting in the streets would cost £700, as against £500 for gas, per annum. A fair estimate for the year's working was: Income, £2,376, and expenditure, £1,710, leaving £666 available towards paying interest and redemption of capital.

Mr. Rankin is the suggested electrical engineer, at a salary of £175 per annum.

Business Announcement.—Mr. G. Straus asks us to state that the fact of his having lately relinquished one of his agencies for incandescent lamps interferes in no way with his business. He continues to supply lamps as heretofore of the same quality and make as formerly. Moreover, he has made arrangements to have a much larger and better assorted stock on hand for immediate delivery.

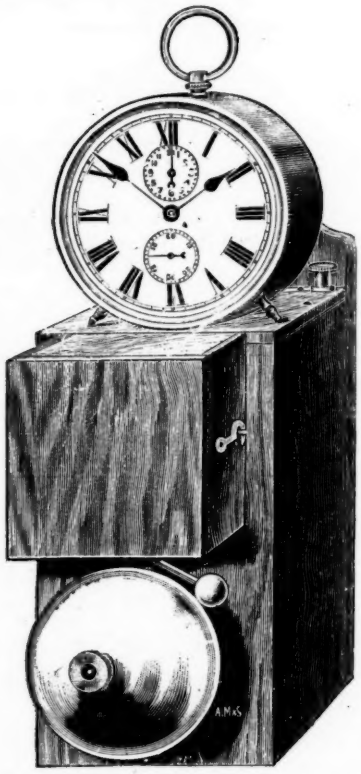
Candlestick Fittings.—Mr. H. N. Warburton, of Portsmouth, is supplying Barter's patent candlestick fitting, which has been designed to enable any candlestick to be adapted for the electric light without much trouble. The fitting (carrying lamp-holder and shade carrier) is inserted in the candlestick socket, where it is kept firm and upright by means of the three steel springs with which it is provided. It is intended for use with a wall socket and flexible cord, which can be connected to the fitting either through a hole at the side or from below if the candlestick permits. The same house supplies the Webber standard (designed by Major-General Webber), which is for use both as a standard and also as a wall bracket for lighting up pictures and other illuminating purposes. It is provided with a curved arm, so that it may be fixed to an arm-chair for use as a reading or writing lamp fitting.

Change of Address.—The registered address of the Electric Construction Company, Limited, from 12th inst., is Dashwood House, No. 9, New Broad Street, London, E.C. The Acme and Immisch Electric Works, Limited, have also removed from Queen Street Chambers to the same address as the Construction Company.

Change of Name.—Mr. Thomas Smith, of 46, South Hill Park, Hampstead, Middlesex, and Broad Street Avenue, E.C., accountant, late Secretary to the General Electric Power and Traction Company, Limited, has assumed and adopted the name of Featherstone in addition to his present name, and that hereafter he will be known by the name of Thomas Featherstone Smith.

Dissolution of Partnership.—The partnership lately subsisting between F. W. Ball and E. D. C. Bolland carrying on business as electrical engineers at Unity Street, Bristol, as F. W. Ball and Company, has been dissolved by mutual consent. All debts due or owing by the late firm will be received and paid by F. W. Ball.

Electric Alarm Clock.—An electric alarm clock is being introduced by Messrs. A. Mayer & Son, of Aldersgate Street, E.C. The invention is a method of actuating the contact-maker, which is the most important part of an electric alarm. It is claimed that the "X L" alarm contact-maker will always make a good electric contact under all ordinary circumstances. The necessary parts are fitted with platinum contacts. The set comprises a



small bell and an E.S. dry battery, or ordinary Leclanché battery, as may be preferred. The battery and bell movement are enclosed in a stained pine case, as shown in the block. The uses for which the clock are recommended are as follows:—Day-time: clock used as a separate timepiece, electric alarm used separately as a door bell. Night-time: clock and electric alarm connected as an alarm clock, and connected to doors or windows as a burglar alarm. The clock may be attached in a few moments to work with any existing bell installation.

E.P.S. Accumulators.—The following is a translation of a testimonial which has been received by the Electrical Power Storage Company from Göteborg:—"The accumulator locomotive which Messrs. Edwin Andrén & Co., in January, 1892, supplied to the Skutskär Sawmills, has, since that time, had her accumulators charged 631 times, in all about 2,000 hours, and, up to the present, not a single one of the accumulator plates has been destroyed or been required to be replaced, all plates continuing to be in full working order. Skutskär, September 12th, 1894. Stora Kopparbergs Bergslags Atkiebolag (Skutskärs Sagverk).—(Signed) Knut Sundblad.

Factory Electric Lighting.—The new and extensive margarine factory of Otto Mönsted, at Southall, has a complete system of arc electric lighting both inside and outside. This factory in a short time will comprise quite a self-contained village, as a number of residences are to be built for the operatives and managers. There is a water supply upon the premises which is to be laid into the houses as well as the electric light. The fire mains, with hydrants and hose, as well as patent ladders, have been supplied by Heathman and Co.

Medical Electrical Institute, Limited.—A petition for winding up the above company was presented by Jas. Willing (the younger), of 125, Strand, W.C., a creditor, on 6th inst. The petition will be heard at the Law Courts on 20th inst.

New Agency.—Messrs. Conze & Simon, of Queen Victoria Street, have taken over the agency of the Elektricitäts-Actien-Gesellschaft, late W. Lahmeyer & Co., of Frankfort-on-Main, a firm well known among electrical engineers. They specially made their mark by being one of the first to undertake the transmission of power over long distances, for instance, supplying the Frankfort Electrical Exhibition with motive power from the Lauffen Waterfalls, &c. Besides the above, they also supply the trade with cut-outs in all sizes, switches, ceiling roses of various types, balance weights, flexible cord, arc lamps and resistances, the Constantia glow lamps, and Paris bronzes suitable for electric lighting purposes.

New & Mayne.—Mr. J. A. Kinney, late electrical engineer with Shirras, Laing & Co., Aberdeen, and formerly with J. H. Holmes and Co., Newcastle-on-Tyne, has joined the staff of Messrs. New and Mayne at 6, Schoolhill, Aberdeen.

Presentation.—On the occasion of his promotion to be engineering clerk of works at the new post office, Leeds, Mr. R. Gill was recently presented with a very handsome case of tobacco pipes from the drivers and stokers at the General Post Office electric lighting station.

Price Lists.—Messrs. Johnson & Phillips have issued a new price list (February, 1895), of pure and vulcanised rubber-covered cables and wires. This firm's cables are used by very large numbers of the most important electrical wiring firms, and quantities of high tension rubber-covered cables are also furnished by them to various supply stations for use underground. These latter cables are tested previous to the ordinary galvanometrical test, with an alternating current of from 4,000 to 10,000 volts pressure from core to earth. A table of copper conductors arranged in order of carrying capacity, also tables giving details of the various classes of cables and wires with weights, prices and code words, occupy the greater number of pages. The general setting out of these tables has been most excellently done, everything being easy to trace out. The printing has also been carefully executed. At the end of the list is a full page illustration of cable-making machinery as designed and constructed by Messrs. Johnson & Phillips.

From Messrs. Ashton, Green, Mathews & Co., we have received a list of their manufactures of slate bases for electrical purposes.

Wilkinson's Valvometer.—This instrument is designed as an aid in the setting, re-setting, adapting, designing or altering the slide valves of steam and other engines. It is well known that in designing the valves of a steam engine the cylinder port areas are fixed upon for a certain steam velocity (varying from 100 to 250 feet per second), and it is also usual to fix a certain amount of "lead," that is, a certain area of port open to steam at the commencement of the stroke. The lead having been equalised at both dead centres, the "cut-off" is tried, and if found to be too late, the lap on the valve and its angle of advance are increased so as to make an earlier cut-off while preserving the same lead. If this does not give sufficient opening to steam, the cylinder ports may have to be enlarged by making them longer; or if their width is increased the "throw" or "eccentricity" of the eccentric sheave will have to be increased. Such points as these are determined, in some cases, by the aid of Zeuner's diagrams, and sometimes by more or less rough models with paper strips. The valvometer has been found of use in all such problems, and specially in trying beforehand the effect of any alteration it may be deemed necessary to make in the valves of an engine. Further, on account of the facility with which the effects may be

observed of changes in lead, lap, angle of advance and travel, upon the points of admission, cut-off, release and compression, the instrument is a valuable aid to professors and others who wish to demonstrate these actions, and show how valves are designed and set. The instrument consists mainly of two eccentrics, each of which has two independent adjustments, viz., one by which the "throw" or distance between the centres of crank shaft and eccentric can be varied, and one by which the eccentric can be shifted round the shaft so that the centre line through the full part of the sheave can be fixed at any angle of advance on the crank. The eccentrics (upon the crank handle being turned) set in motion two sliding bars, and by the above adjustments these bars can be given any motion in relation to each other or the crank, or their amount of travel may be varied at will. Mounted on these bars are other bars (hereafter called valve blocks) whose position can be adjusted in the direction of travel. By

means of this adjustment, after the valve ports have been marked out on the surface of the valve blocks, the latter can be shifted in exactly the same way as when setting an engine valve for the purpose of equalising the lead and cut-off. A pointer is carried by each eccentric coinciding with the full part of the sheave, and indicates on the graduated half-circle its angular position. Thus the crank being set at one or other dead centre, the eccentric sheave may be set, by means of the pointer to any angle of advance on the crank, for either way of rotation of the engine. To avoid adding further parts to the valvometer, and to keep it within compact limits, no section has been added to represent the piston, cylinder and stroke of any engine whose valves are being set out on the instrument. On the other hand the method of determining the position of the piston adopted, covers any length of stroke and any ratio of connecting rod to crank, which saves considerable complication, and gives the exact determination required. The instrument simply has a crank arm moving over a scale of angles from 0 to 180°, viz., from one dead centre to the other; and by reference to the tables the corresponding position of the piston in the cylinder is found for any given ratio of connecting rod to crank. Supposing the crank to have moved through any given angle from zero, it is required to know how far the piston or crosshead has moved from the commencement of the stroke. This is usually expressed as a fraction of the stroke, thus definitely fixing the position of the piston whatever may be the actual length of stroke. Now the angle moved through by the crank when the piston has travelled a given portion of the stroke, is more or less according as the connecting rod is long or short. For example, in an engine in which the connecting rod is two-and-a-half times the length of the crank (or one-and-a-quarter times the stroke) the crank will have moved through 109° from zero or the back dead centre, while the piston has travelled three-quarters of the forward stroke; but if the connecting rod is, say, six times the crank (or three times the stroke), the crank would have moved through 115½°. On this account it is necessary to take into account the ratio between the length of connecting rod and crank in any engine whose valve action is being examined, and knowing this ratio the angle of the crank corresponding to any fraction of the stroke travelled by the piston or crosshead can be found. The instrument is manufactured by Messrs. Nalder Bros. & Co., which is sufficient evidence that it is well made.

United States Patents.—Mr. J. G. Lorrain writes us as follows:—"It may interest those of your readers who apply for United States patents to know that on and after April 15th next, the time for answering Examiner's objections will be six months instead of two years as has formerly been the case. This change will prevent the repetition of such cases as have been referred to in your journal, whereby patent applications have been kept from issue for many years in order to prolong monopoly. This alteration in the United States rules of practice is a result of the Government suit against the American Bell Telephone Company, which was reported in your columns at the time."

CONTRACTS OPEN AND CLOSED.

OPEN.

Austria.—April 1st. Tenders are being invited by the Kaiser Ferdinand Nord Railway authorities in Vienna for the supply and erection of the necessary plant and apparatus for the electric lighting of the railway station in that city. The contract calls for the supply of two tubular boilers, feed pumps, two sets of direct-connected engines and dynamos, an overhead travelling crane, and forty arc lamps, &c.

Bradford.—March 28th. Tenders are invited for the construction and delivery of two steam dynamos for the electricity works at Bolton Road, of the Corporation. Details may be had on application to Mr. Baynes, Electricity Department, Town Hall, Bradford.

Bulgaria.—Tenders are being invited by the Bulgarian Posts and Telegraphs authorities in Sofia for the supply of 43 tons of bronze wire, 3 mm. in diameter, 15,000 porcelain insulators, 12,000 iron hooks, and 1,400 double hooks, &c. The material is required for a telephone line which it has recently been decided to construct between Sofia and Rustchuk, a distance of about 230 miles. The line is to be erected on the existing telegraph poles.

Derby.—March 18th. Tenders are invited for the construction of three mild-steel Lancashire boilers and their accessories, for the Corporation of Derby, in connection with their electric lighting works. Details on application to Messrs. Bramwell and Harris, 5, Great George Street, Westminster, S.W.

France.—April 1st. The Société Lyonnaise des Forces Motrices du Rhône, of Lyons, is inviting tenders for the supply of the necessary electrical machinery for the central station they are about to establish, to utilise the water power of the Rhône.

France.—March 21st. The General Direction of the French Posts and Telegraphs in Paris is inviting tenders until the 21st inst. for a quantity of electric cables.

Norwich.—April 2nd. Tenders are being invited by the Corporation for the erection and fitting up of new baths. The work is split up into five items, "E" referring to an electric light installation. Details are to be obtained from Mr. A. E. Collins, A.M.I.C.E., city engineer, Guildhall, Norwich.

Spain.—March 27th. The Directors of the Electricity Supply Company for Spain, Limited, invite tenders for the supply and erection of certain machinery, &c., for the extension of their electricity works in Madrid. All details may be obtained at the offices of the company, 15, St. Helen's Place, E.C., or of Mr. Robert Hammond, the consulting engineer, Ormonde House, Great Trinity Lane, London, E.C.

Spain.—The Spanish Minister of Public Works in Madrid is inviting tenders for the concession for the establishment and operation of a telephone exchange at Motril, a small seaport town in Granada.

CLOSED.

Ayr.—It has been decided to accept the following tenders in connection with the electric lighting works:—Mason, &c., work, £3,303 6s. 4d.; carpenter, joiner, and painter work, Messrs. D. & J. Milligan, £1,146 13s. 4d.; slater and plumber work, Messrs. W. Highet & Son, £356.

Birmingham.—We stated last week in error that a tender had been accepted for lighting and fitting up the technical school. The matter is not yet settled.

London, E.C.—Messrs. Edward Le Bas & Co. have just secured the contract for the whole of the lap-welded wrought-iron pipes required by the City of London Electric Company for their cable conduits; delivery to extend over a certain time.

NOTES.

Electric Lighting in Paris.—Since 1888 the City of Paris has made several grants to companies for electric lighting, and has even established several lighting installations. M. J. Laffargue, electrical engineer to the City of Paris, has just published in *L'Industrie Électrique* for February 25th, 1895, certain results which, unfortunately, only relate to the year 1893. The following table gives the particulars relating to the working of the various companies holding sectors in December 31st, 1893:—

	No. of consumers.	No. of lamps.		Length of mains in kilometres.	Kilowatt-hours distributed.	Total receipts in francs.
		Arc.	Incandescence.			
Edison Co. ...	1,208	784	43,978	32,868	1,586,371	1,897,293
Compressed Air Co., Paris	930	1,566	34,758	49,788	1,144,082	1,338,027
Lighting and Power Co. ...	1,061	2,391	46,996	49,318	1,253,482	1,298,632
Place Clichy sector ...	1,025	721	48,020	45,866	740,826	939,572
Champs Elysées sector	260	91	27,925	42,020	133,503	169,867
Left Bank sector ...	4	4	130	·949	3,034	295

The municipal electric lighting, included, in 1893, the lighting of the Place Carrousel, the lighting of the outer galleries of the Palais Royal and the entrances to the Théâtre Français, the line of the large boulevards from the Place de la Madeleine to the Place de la République, the Rue Royale, the Rue Saint-Lazare, the quays of Jemappes and Valuiy, the Avenue de Clichy, the Boulevards Ornano and Barbes, the Boulevard de la Villette and round the fountain, and also the Place des Pyrénées. This lighting was effected by 298 arc lamps of 10 ampères, supported by posts 4 metres high. They were lighted from dusk till one o'clock in the morning. The total expenditure for this lighting amounted in 1893 to 430,639 francs. The municipal electrical station of the Halles Centrales produced in 1893 a total of 1,110,666 kilowatt-hours, 491,000 being devoted to the lighting of the Halles Centrales, 23,000 kilowatt-hours for the ventilation, and the remainder for various consumers. The total receipts amounted to 563,254 francs, and the expenses to 515,326 francs, not including the expenses of interest and the sinking fund. But it is very difficult to draw conclusions from these figures, for the city of Paris has a special mode of reckoning, and only reckons a very small portion of the expenses. On the 31st December, 1893, the lighting of the Halles Centrales comprised 471 incandescence lamps and 252 arc lamps of 5 and 10 ampères. The lighting for private consumers included 381 arc lamps

and 6,197 incandescence lamps. The municipal electrical station of the Champ de Mars, with a total power of 372 kilowatts, supplies the luminous fountains. The expenses for 1893 amounted to 62,215 francs. The municipal electric installation of the Bourse du Travail, which is supplied by the sector of the Société d'Eclairage et de Force, was not working in 1893. The lighting of the *entrepôts* of Beircy, which was undertaken at the expense of the city of Paris by M. V. Popp, involved an outlay of 18,000 francs. The slaughter-houses and the cattle market of La Villette are lighted by electricity, at the expense of the city of Paris, by the Société d'Eclairage et de Force, who have established a station with a total power of 330 horse-power. The installation comprises 128 8-ampère arc lamps, 16 6-ampère arcs, 533 16-candle incandescence lamps, and 87 10-candle incandescence lamps. The working commenced December 20th, 1893. The annual expenditure is estimated at 168,600 francs. The Fire Brigade Station in the Rue Jeanne d'Arc is lighted by 28 incandescence lamps; the expenses of maintenance were 3,415 francs in 1893. The municipal electrical station of the Hôtel de Ville has a total power of 200 kilowatts, and supplies the lighting of the council halls and the banqueting halls. The expenses amounted to 40,000 francs in 1893. To complete the summary of the municipal electric lighting of Paris, we must add the electric lighting of the Parc Monceau, the Parc du Buttes-Chaumont, and the Square des Batignolles. The lighting of the Parc Monceau and the Parc du Buttes-Chaumont is effected from two municipal stations, the first of 30 kilowatts, and the second of 50 kilowatts. The expenses of working in 1893 were respectively 19,955 and 33,123 francs. The Square des Batignolles is lighted by eight 8-ampère arc lamps, fed by the sector of the Place Clichy. The expenses in 1893 were 2,817 francs.

Tailoring and Electrical Engineering.—We give the following advertisement from the *Oldham Standard* simply as a curiosity. A firm which can sell men's Cardigan jackets for 1s. 11d., and can undertake "high-class installations only," deserve more than passing notice.

Not open on Tuesdays.—J. and P. Dyer.
Drink Wine at the Café in Curzon Street.
Drink Wine at the Café in Curzon Street.
Overcoats at 15s., Ready-made.—J. and P. Dyer, near Electric Four Lamps.
Overcoats to Measure, 25s.; best Melton Cloth. Cannot be Beaten.—J. and P. Dyer.
Overcoats to Measure, 27s.; Best Kyrle Serge.—J. and P. Dyer's, near Electric Four Lamps.
Overcoats to Measure 35s.; Splendid Beaver Cloth, cheap line.—J. and P. Dyer's, near Electric Four Lamps.
Electric Lighting. High class installations only. J. & P. Dyer's, Electrical Engineers, 39B, Market Place, Oldham.
Love flies out of the window, when dirt comes in at the door—VENUS SOAP saves rubbing, cleans and purifies everything quickly and easily.
Men's Cardigan Jackets, 1s. 11d., &c., &c.—J. and P. Dyer, near Electric Four Lamps.
Our advice is when away from home dine at the Café in Curzon Street. Dinners from 5d. Teas from 4d. Suppers from 3d. Well cooked, well served, and plenty of it.
We recommend the people of Oldham and district to spend their money with Messrs. J. and P. Dyer, Tailors, Clothiers, &c., &c.
ELECTRIC LIGHTING.—The Brush Electrical Engineering Company, Limited's new 3-Watt lamp uses 25 per cent. less current than ordinary lamps. Sole agents for Oldham and district.—J. and P. Dyer, 39 and 41, Market Place, Oldham, who undertake high-class installation work only.
We make Clothing like Oldhamers make Yarn—by the best machinery in the world for the purpose.—J. and P. DYER, Tailors, Clothiers, Shirtmakers, &c., &c.
Electric Lighting. High-class installations only.—J. & P. Dyer, Electrical Engineers, 39B, Market Place, Oldham.

The Reporter of the "Western Mail."—A reporter of the *Western Mail* is born for greater things than reporting. He says: "Coming from generalities to details, why is it that the Cardiff electric mains show such an abnormal leakage of energy as is the case to-day? Anyone with a turn for experiment may light an 8 candle-power lamp from such leakage. All that is needed is a wire attached to any terminal at one end, and to earth at the other, with a lamp in the middle, and an 8-candle-power light is the immediate result." On the whole we prefer the reporter's generalities to his details.

Society of Arts and the Albert Medal.—Early in May the Council of the Society of Arts will consider the award of the Albert Medal for 1895, and members of the Society have been invited to send in, by April 13th, names of those considered worthy of this honour. The following are the names of those connected with electrical and allied sciences and industries who have succeeded in securing the medal since 1864:—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S., "for his great services to arts, manufactures, and commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1866, to Michael Faraday. D.C.L., F.R.S., "for discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted arts, manufactures, and commerce."

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Prof. (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to manufactures and the arts."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., late Astronomer Royal, "for eminent services rendered to commerce by his researches in nautical astronomy and in magnetism, and by his improvements in the applications of the mariner's compass to the navigation of iron ships."

In 1879, to Sir William Thomson (now Lord Kelvin), LL.D., D.C.L., P.R.S., "on account of the signal service rendered to arts, manufactures, and commerce, by his electrical researches, especially with reference to the transmission of telegraphic messages over ocean cables."

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S., "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science to industrial pursuits."

In 1888, to Prof. Hermann Louis Helmholtz, For. Memb. R.S., "in recognition of the value of his researches in various branches of science, and of their practical results upon music, painting, and the useful arts."

In 1889, to John Percy, LL.D., F.R.S., "for his achievements in promoting the arts, manufactures, and commerce, through the world-wide influence which his researches and writings have had upon the progress of the science and practice of metallurgy."

In 1891, to Sir Frederick Abel, K.C.B., D.C.L., D.Sc., F.R.S., "in recognition of the manner in which he has promoted several important classes of the arts and manufactures, by the application of chemical science, and especially by his researches in the manufacture of iron and of steel; and also in acknowledgment of the great services he has rendered to the State in the provision of improved war material, and as chemist to the War Department."

In 1892, to Thomas Alva Edison, "in recognition of the merits of his numerous and valuable inventions, especially his improvements in telegraphy, in telephony, and in electric lighting, and for his discovery of a means of reproducing vocal sounds by the phonograph."

Correction.—Mr. W. B. Sayers writes us as follows:—"Through an oversight of mine, the formula for size of machine given on page 272 of your issue of March 1st, is printed

$$N = \frac{\text{machine constant}}{1} \times 1{,}350{,}000.$$

This should be

$$N = \sqrt[2]{\text{machine constant} \times 1{,}350{,}000}.$$

Would you kindly put a note in your forthcoming issue correcting this, and if you can spare the space, adding that recent calculations show that the figure 1,350,000 can be greatly reduced in machines of my type."

Northern Society of Electrical Engineers.—The first annual report of this society states that the founders and officers have not been idle. During the session 1893-94 there were six papers read and discussed, and during the summer recess excursions were made to local electrical works and to the Antwerp Exhibition. When the Society was founded there were 80 members, and at the close of 1894 there were 122 members and three associates on the roll. The financial position of the Society is also very satisfactory, there being £158 at the bankers. We think these results show ample reason for the existence of the Society, and we have no doubt that the success that now favours it will continue. Attached to the report is a list of the members' names, also a copy of the rules.

The Handling of Coal and Ashes.—Central stations in this country have done a good deal to improve the methods of handling fuel, and we have described at different times various efficacious ways of feeding the furnaces. In the third district station of the Brooklyn Illuminating Company, a combined system of dealing with coals and ashes has been adopted which we do not remember to have seen before. The station is situated at some distance from the coal wharves, and coal is delivered by waggons. It was necessary to take the coal from the waggons, carry it to the furnaces, and also to remove and dispose of the ashes. The coal is carried from the hopper underneath the sidewalk to the coal tanks above the boilers by a conveyor which upon its return passes underneath the ash pit of the furnace and carries the ashes to a bin from which they can be drawn at will for removal. The conveyor consists of a series of gravity buckets pivoted in a double chain, and the whole system is carried on self-lubricating wheels. The buckets are so pivoted in the chain that the force of gravity keeps them always in an upright position. The change in the direction of the conveyor is made by running around curves instead of over sprocket wheels, and the whole machine is noiseless in its operation. The chain is driven by pawls. The conveyor is moved slowly, the capacity being obtained by the size of the buckets, and not by the speed of the chain. The loading is accomplished by a continuous filler which guides the coal into the buckets, filling each one evenly as it passes. The power for driving the conveyor is furnished by a 10 horse-power electric motor. When receiving coal at its full capacity, the power required to operate the conveyor is 4½ H.P., measured at the switch. The coal is drawn from the storage bins above the boilers into weighing hoppers, from which it is spouted to the floor of the boiler room at such a distance as to be easily shovelled directly into the furnaces. Handling ashes, either wet or dry, has heretofore been considered one of the most difficult objects to accomplish, and one of the most destructive to machinery, but in this station it is accomplished so completely by the use of a special filler placed under each boiler, that it appears to be as easy to handle the ashes as the coal. We have extracted the foregoing from the *Electrical World*.

Bradford, Burnley, and Burton Electric Lighting Accounts.—The following figures have been drawn out by the Bradford Electricity Committee, showing the progress that was made during 1894 as compared with the previous year :—

	1893.	1894.	Increase.
Total income ...	£5,642	£6,349	£707
Gross profit ...	2,876	3,512	636
Working expenses	2,765	2,836	71
Net profit ...	1,179	1,449	270

There has been put to a depreciation fund £1,062, leaving a balance of £387 against £1,179 in 1893. This sum (£387), with the balance from the previous half-year, made the total profits unappropriated on December 31st, 1894, £2,817.

Burnley Gas and Electric Lighting Committee report that, up to the end of March, they had made a profit of £100. For the year, the estimated income was £2,900, and the expenditure, £1,430. Instead of a loss which had been anticipated, they had made a profit. The charges for current are to be reduced as follows :—For lighting purposes, from 6d. to 5d. per unit, and from 4d. to 3d. per unit ; for other purposes, subject to the usual discounts. Application is to be made to the Local Government Board for sanction to borrow £5,500 for additional machinery, and main extensions. Next year (1895) the Committee expect an increase in customers to the extent of about 20 per cent.

Burton Electric Lighting Committee have during the time they have been running incurred a loss of £1,802 9s. 3d. It was anticipated that the loss would be £2,500. The working expenses were £843, and the receipts £528, so that the actual loss without taking into account the sinking fund, was £315.

Sunderland Lighting Successful.—A local paper states that the consumers who are connected with the recently inaugurated system have every reason to be satisfied with the light.

Electricity and Customs Dues.—The *Canadian Gazette* of last week states that a deputation from Niagara Falls, representing the Oneida Manufacturing Company, waited upon the Controller of Customs to ask whether electricity conveyed across the river would be liable to duty. The Controller replied that he would consider the question. Without doubt the Controller thinks that in a country where coal, oil, and other agents for the development of power pay Customs dues, electricity should also do so, in order that home produce be protected; but as there is considerable difference in opinion existing as to what electricity is, it will be curious if the Controller of Customs will be able to find it fully specified in the Customs schedules of dues to be charged. Whether the dues will be collected at so much per pound weight, or at so much per pint measure, or at a certain figure *ad valorem*, would seem to present a puzzle of some magnitude to the Custom House officer who has been able to determine the class under which electricity appears in his Customs list. If the Oneida Manufacturing Company find they are obliged to pay duty, the transatlantic cable companies, which pump current into Nova Scotia, will require to look after their interests. Perhaps a solution of the difficulty may be found in the negative and positive theory of currents, and the Custom House, while charging duty for positive or going in currents from abroad, would give a bounty for negative or going out currents, and by establishing a parity between duty and bounty, solve the whole difficulty.

A Novel Rat Poison.—A very interesting note comes from the *Scientific American*, from which we learn that an enormous business has been done lately at French fairs by a man who professed to sell a rat powder that was perfectly harmless, and that struck rats dead on the spot. In order to convince the sceptical, the man first of all powdered a slice of bread with the stuff and ate a piece of it himself. Then he put the remainder under a glass case, in which a rat was kept in captivity. The rat went to eat the bread and instantly fell dead. At 5d. a box the powder went off like hot rolls, and the lucky proprietor of the specific was in a fair way to make a fortune. But the police, who in France are very active in protecting the people from fraud, looked into the matter, and found that the powder was nothing but ordinary sugar. They also discovered that the case was connected with a powerful electric battery, and that the moment the rat touched the bread the current was turned on, and it was thus his death was brought about.

Wrought-Iron Field Magnets.—The E. G. Bernard Company, of Troy, N.Y., are making what they term the improved Adams dynamo and motor, which have wrought-iron field magnets forged in single pieces, thus eliminating all joints in the magnetic circuit other than the air gap between field and armature. It is claimed that this construction secures a very strong magnetic field with a small number of ampère-turns, and reduces the windings and machine work to a minimum, enabling the manufacturers to produce a high grade machine at comparatively low cost.

Obituary.—The death is announced of a lady of literary and scientific attainments of a somewhat superior character, in the person of Mrs. Andrew Crosse, widow of the well known electrician and scientist, Andrew Crosse, who was born in the year 1784, and died in 1855, leaving her with three infant sons. Mrs. Crosse was at one time a familiar figure at British Association meetings, and the world has lost in her an enthusiast of the sciences for which few of her sex have so great a liking.

Chess by Cable.—All chess-players will be interested in the chess match, with ten players aside, which took place on Saturday last between the British Chess Club, of London, and the Manhattan Chess Club, of New York. The Commercial Cable Company's cables were used, and over 560 messages were sent between the hours of 3 and 12 p.m, some of the messages getting through in 15 seconds. The match ended in a draw.

Walsall Extravagant.—Walsall will not over-burden its engineer with salary. It wants one at a stipend of £150.

Personal.—Prof. Perry has been obliged, in consequence of a severe attack of the prevailing epidemic, to postpone till after Easter the remainder of his course of special lectures on "Reciprocating Machinery," at the Technical College, Finsbury. In the meantime, Mr. Miles Walker will give, as a short course of lectures on Thursday evenings, an "Introduction to the Vector Calculus."

The Institution of Electrical Engineers.—At a students' meeting, to be held in the library of the Institution, 28, Victoria Street, on Friday, March 22nd, 1895, at 8 p.m., the following paper will be read:—"Lead-covered Cables," by Mervyn O'Gorman (Fowler-Waring Cables Company).

Cardiff Electric Lighting.—We publish in our "Correspondence" columns a letter from Mr. Massey, bearing on the remarks we made last week on Cardiff lighting. So far from Mr. Massey being responsible for the list of duties on which we commented, we believe that on questions of general policy and management, or of the best arrangement of working the station, his suggestions have been entirely disregarded. The financial position of the whole Borough of Cardiff is by no means cheering just now, but in view of the fact that the waterworks have absorbed over £1,000,000, and the expenditure is still increasing, we shall certainly resent any attempt to make electric lighting the scapegoat of the great increase of rates which will devolve upon the ratepayers. It is a thousand pities that *the* journal which is in touch "with what is going on in the electrical world," has not the courage to speak openly on this matter. Need we ask why?

New Method of Hiving.—How doth the busy bee improve each shining hour? We have just learned how it is done:—"A German electrician recently hived a swarm of bees by the use of electricity. He passed a powerful current *through the bough of a tree* on which they clustered, and the shock caused them to fall stupefied to the ground. Before they had time to recover, he had them collected and placed in a new hive." The foregoing is from *Pearson's Weekly*.

Government and the Telephone.—The following is a list of the committee appointed by Parliament, on Wednesday, to consider the telephone agreement:—Captain Bagot, Mr. Baird, Mr. Benn, Sir C. Cameron, Mr. John Ellis, Sir J. Fergusson, Sir J. Goldsmid, Sir J. Gorst, Mr. Grant Lawson, Mr. Solicitor-General, Mr. Arnold Morley, Mr. Moulton, Mr. Snape, Lord Stanley, and Mr. Tully.

A New Pacific Cable Scheme.—A Reuter despatch from New York, dated March 9th, stated that a project is now under consideration whereby Russia, France, Japan, and Hawaii will join an American company in constructing a telegraph cable from San Francisco to Hawaii, and thence to Japan and the French islands in the Pacific. The negotiations are almost concluded.

Researches on Graphite.—Mons. Henri Moissan continues to prosecute his researches with his electric furnace, and every now and then to contribute a paper upon them to the Paris Academy of Science. One of the latest (*vide Comptes Rendus*, December 10th, 1894) refers to his researches on the different varieties of graphite which can be obtained (*a*) by the action of high temperature on carbon; and (*b*) by the crystallisation of carbon from a metallic solvent. His experiments were conducted with a current of 350 ampères, 70 volts, by means of which he succeeded in preparing graphite in several different forms, each possessing different physical, if not chemical, properties. The most interesting way of preparing these graphites appears to be from carbon obtained from sugar, and then dissolved, under the influence of the heat from the arc, in such metals as aluminium, uranium, nickel, tungsten, zirconium, &c. It seems, however, that whatever the source of the carbon, graphite can always be obtained from it by subjecting it to the conditions imposed in the electric furnace. Mons. Moissan has certainly succeeded in adding to our knowledge concerning graphite, and it is to be hoped that sufficient data will soon be accumulated to enable some broad generalisations to be made in connection with those electrical matters in which the substance plays so important a part.

Lectures.—Before the Twickenham Literary Scientific Society on 5th inst., Mr. W. J. Alexander, A.I.E.E., lectured on "How we measure electricity." The lecture was illustrated by experiments and lantern slides.

Prof. W. C. Unwin, F.R.S., M.Inst.C.E., has undertaken to deliver the "James Forrest" lecture at the Institution of Civil Engineers on Thursday, May 2nd, and proposes to deal with the "History of the Experimental Study of Heat Engines."

The National Telephone Dinner.—The second annual staff dinner will take place at the Holborn Restaurant to-night.

The Royal Society.—Before this Society, yesterday afternoon, the Croonian lecture, "On the Nature of Muscular Contraction," was delivered by Prof. T. W. Engelmann.

Madras Electric Tramways.—These tramways are now in working order. Several trial trips were made on the first section over a month ago.

Mr. Tesla's Works Destroyed by Fire.—A Reuter's telegram, reproduced in yesterday's *Western Mail*, states that Mr. Tesla's works have been destroyed by fire. The whole of his extensive plant, and all his specially-designed apparatus for conducting experiments were destroyed. The damage is estimated at $100,000, but the greatest loss is the physical collapse of the inventor from the shock caused by the disaster.

Conductivity of Electrolytes.—In the case of strongly dissociated compounds, it has been found by several observers that pressure affects the electrical conductivity, and it has been suggested that the effect is due chiefly to the alteration which assumedly takes place in the velocity of the ions. I. Fanjung has recently, following in the footsteps of Fink, made a large number of observations upon slightly dissociated compounds, with a view of discovering whether these behave in the same way. He determined the conductivity of various organic acids and salts at various degrees of concentration, and at pressures varying from 1 to 260 atmospheres. In all cases he found that pressure caused a decrease in the electrical resistance, the alteration at 260 atmospheres varying from 6·55 to 9·02 per cent. in the organic acids, and from 1·23 to 2·92 per cent. in the more strongly dissociated compounds. The rate of increase in conductivity is not constant; in most cases it decreases with increasing pressure. Fanjung suggests that in the highly dissociated compounds the alteration is most probably due to the diminution of the internal friction, and as the alteration of the fluid friction of the water is comparable with the change in resistance of these solutions, it appears that an alteration of internal friction of the solvent is associated with an approximately equal alteration in the ionic friction.

The Electrolysis of Copper Sulphate.—It is a well known fact that when a solution of copper sulphate is subjected to electrolysis whilst hot, a curious violet-red deposit is thrown down, concerning which there has been some speculation. This matter has recently been investigated by Mons. A. Chassy, who contributes a paper on his results to the *Comptes Rendus*, cxix., page 271. He finds that when platinum electrodes are used, and a current of 0·01 ampère per square centimetre, an almost neutral and saturated solution of pure copper sulphate yields, if the temperature be maintained at 100° C., a bright red deposit of microscopic crystals. These consist of cuprous oxide. If the temperature be kept below 100° C., the oxide becomes mixed with crystals of metallic copper, the proportion of which is higher the lower the temperature. A similar effect is produced by increasing the strength of the current, or diluting the solution. If the positive electrode consists of copper, its loss of weight is always distinctly lower than the gain in weight of the negative electrode. Moreover, if the voltameter containing the hot solution is connected in the same series with a voltameter containing a cold solution of copper sulphate, the weight of the deposit in the former is always much greater than would correspond with the oxidation of the copper deposited in the latter.

How to Fit Up a Laboratory for Analyses by Electrolysis.—Those who are about to fit up or remodel a laboratory for chemical analysis by electrolysis cannot do better than consult a recent paper by A. Classen in the *Berichte der Deutschen Chemischen Gesellschaft*, xxvii, page 2,060, where they will find a lucid description accompanied by plans and a sketch, of the manner in which the private laboratory in the Laboratory of Inorganic Chemistry at Aix-la-Chapelle is fitted up for electrolysis. At the bench 24 electrolyses can be carried on simultaneously, and the current in each electrolytic cell can be measured by an ampèremeter common to the whole set. The usual method of measuring the current with a gas voltameter before the electrolysis is commenced has been condemned by Classen as very faulty. He uses, therefore, an ampèremeter, which can be thrown into circuit during electrolysis by adjusting a copper bridging wire between two mercury cups. When the measurement is made the bridge is removed and connection made, so as to cut off the ampèremeter; but this time by means of a bridge having a resistance exactly equal to that at the time of measurement. The paper concludes with an elaborate account of the chief method of electrolysis employed at Aix-la-Chapelle.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Julius Sax & Co., Limited (37,435).—The annual return of this company, made up to January 3rd, and filed recently, shows that the whole capital of £20,000 in £10 shares has been taken up, 1,993 shares have been issued as fully paid, and nothing has been paid on the other seven shares.

London Electric Wire Company, Limited (36,544).—The annual return of this company was filed on February 12th, when 4,188 preference and 4,597 ordinary shares were taken up, out of a capital of £50,000 in £5 shares (of which 5,000 are preference and the rest ordinary); 3,860 preference, and a like number of ordinary, have been issued as fully paid, and the full amount has been called on the others. £5,325 has been paid in respect thereof.

Direct United States Cable Company, Limited (11,597).—The annual return of this concern was filed on February 15th, when 60,710 shares were taken up out of a capital of £1,300,000, in £20 shares, and all were issued as fully paid.

Lineff Electric Traction and Lighting Syndicate, Limited (27,246).—The annual return of this company, made up to January 3rd, was filed on January 8th following. The capital is £15,000, in £1 shares, and 11,431 shares have been taken up. 8,003 have been issued as fully paid, and the full amount of £1 per share has been paid on the remainder.

Eastern Telegraph Company, Limited (6,338 C.).—The annual return of this company was filed on March 7th, when 469,988 shares were taken up out of a capital of £4,700,000 in £10 shares. The full amount has been called and paid upon all of these shares.

St. James's and Pall Mall Electric Light Company, Limited (26,015).—The annual return of this company, filed on March 6th, shows that the whole nominal capital of £200,000, in 100 founders' shares of £1, and 19,980 ordinary and 20,000 preference of £5 each has been taken up, and the full amount has been paid on each.

Cuba Submarine Telegraph Company, Limited (4,710 C.).—The annual return of this company, which was filed on March 7th, indicates that all the capital, viz., £220,000 in £10 shares, has been taken up and paid for in full.

Charing Cross and Strand Electricity Supply Corporation, Limited (29,122).—The annual return of this company, made up to March 7th, was filed on March 9th following. The capital has recently been increased from £150,000 to £250,000 in £5 shares, and the original 30,000 shares have all been taken up and paid for in full.

Yorkshire House-to-House Electricity Company, Limited (29,235).—The company's usual return, filed on February 22nd, shows that 10,000 ordinary and 100 founders' shares have been allotted. The latter have been issued as fully paid and £5 per share has been called on the ordinary, with the result that £49,980 has been paid, and £20 is still in arrears. The capital of £100,000 is divided into 19,900 ordinary and 100 founders' shares.

Irish House-to-House Electricity Company, Limited (29,226).—This company did not file its returns for 1892, 1893, and 1894, until January 7th last, when 100 founders' and 527 ordinary shares were taken up out of a capital of £100,000 in 19,900 ordinary and 100 founders' shares. The founders' shares have been issued as fully paid, and 10s. per share has been called on the ordinary. £202 has been paid in, and £61 10s. has yet to be received.

"Lightning," Limited (35,318).—This company's annual return, made up to January 14th, and just filed, shows that all the 3,000 £1 shares in the nominal capital have been taken up. Of this number 600 are founders, and 300 of these have been issued as fully paid. £2,700 has been paid on the remainder in reponse to calls.

Leeds and London Electrical Engineering Company, Limited (32,497).—This company filed its 1894 and 1895 returns on February 2nd, when 250 founders', 734 preference, and five ordinary shares were subscribed for out of a capital of £100,000, in £5 shares (250 founders', 9,750 preference, and 10,000 ordinary). The full amount has been called on all, except 100 preference, which have had £1 per share called, and £4,545 has been paid.

Arc Accumulator Company, Limited (34,015).—The annual return of this company, which has just been filed, shows that the £1,000 £1 shares in the capital have been taken up, and 993 have been issued as fully-paid. Nothing has been paid on the remainder.

CITY NOTES.

City of London Electric Lighting Company.

We have already spoken of the report of the City Company, so we do not propose at the moment to do more than give the following analysis of the cost of production. The number of units sold for 1893 and 1894 include public and private lighting.

	1892.	1893.	1894.
Total capital invested	—	£799,610	£989,453
Number of units sold	—	1,741,099	2,532,0 0
Number of lamps connected ...	—	65,341 & 502 arcs	135,460 and 502 arcs
Revenue from sale of current...	—	£37,156	£63,271
Net revenue	—	—	£33,045
Average price obtained per unit	—	7·5d. private	7·9d. private

Cost of production.	Private.	Per unit.	Public.	Per unit.
Coal	£10,481	1·64d.	£3,949	·94d.
Oil, waste, water and engine room stores	1,746	·27d.	1,773	·42d.
Salaries and wages at generating station	6,231	·97d.	3,804	·91d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c. *	Works' cost 2·88d.		Works' cost 2·27d.	
Rates and taxes	1,466	·23d.	733	·17d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	2,647	·41d.	1,273	·30d.
Depreciation of buildings and plant account	—	—	—	—
Renewal fund account	—	—	—	—
Total	£22,571	3·52d.	£11,532	2·74d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	63,271	0	11	7·9d. private
Meter rents	2,523	3	8	—
Sale of Lamps	—			—
Total	£65,794	4	7	

* Repairs and maintenance, as well as statutory depreciation, have been provided out of the depreciation reserve funds.

Total cost per unit, private lighting (exclusive of depreciation and renewal accounts), 3·52d.; works' cost, 2·88d. Total cost per unit, public supply, 2·74d.; works' cost, 2·27d.

The Hove Electric Lighting Company, Limited.

The report records most satisfactory progress. The number of lamps attached to the company's mains has increased from 6,915 8's to 16,473. The sale of current per meter, which realised £1,266 during 1893, shows an increase to £3,508 during 1894, while the result of the last year's working has been a profit of £1,243, as against £77 for the previous 12 months. After deducting £563 17s. 11d. for interest accrued on loans and debentures, a net balance remains to the credit of revenue account of £679 2s. 6d., as compared with a corresponding figure of £1 2s. 8d. at the close of 1893; £73 is to be written from the suspense account, and a dividend of 3 per cent. per annum is to be declared. We learn from the report that while the debentures offered to the public in March last were readily subscribed, the shares were not taken up well, so further capital is now required to

discharge the banker's loan, and to meet liabilities to the contractors and the cost of additional machinery which will be required to meet the increased demand for current next autumn. The accounts analyse as follows:—

	1892.	1893.	1894.
Total capital expended ...	—	—	£48,828
Number of units sold	—	—	107,218
Number of lamps connected ...	—	—	16,473
Revenue from sale of current...	—	—	£3,617
Net revenue	—	—	£1,243
Average price obtained per unit	—	—	7·8d.

Cost of Production.	£	s.	d.	Per unit.
Coal	606	0	0	1·35d.
Oil, waste, water, and engine room stores	114	0	0	·25d.
Salaries and wages at generating station	525	0	0	1·17d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	233	0	0	(Works' cost 3·29d.) ·52d.
Rates and taxes	164	0	0	·36d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	865	0	0	1·92d.
Depreciation of buildings and plant account	—			—
Renewal fund account	—			—
Total	£2,507	0	0	5·57d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	3,616	19	9	7·8d.
Meter rents	211	11	4	—
Sale of lamps	—			—
Total	£3,828	11	1	7·8d.

Total cost per unit (exclusive of depreciation and renewal accounts), 5·57d.; works' cost, 3·29d.

Henley's Telegraph Works Company.

Last year, when reviewing this company's report and accounts, we expressed regret that the year 1893 had showed a considerable falling off in profit. This year, however, the company has fairly earned the right to be heartily congratulated on the state of the business, especially when we consider that the company has not had during the year a single large contract for submarine cables. From the directors' report we learn that a net profit has been made of £16,455, and after paying interest, and allowing for depreciation of plant, and making other deductions, there remains for disposal a balance of £15,957. £2,180 is to be added to reserve fund, and it is proposed to pay a further dividend on the preference shares at the rate of 7 per cent., and a dividend for the year at the rate of 6 per cent. on the ordinary shares. These payments leave a balance of £8,624 9s. 3d. to be carried forward. The £50,000 4½ per cent. mortgage debenture stock was issued in August last, and the proceeds have been applied to paying off all existing mortgages and debentures, and to provide additional buildings, plant, and working capital.

We made a comparison last year which was not over favourable, and we have, therefore, great pleasure in giving another comparative table, which shows clearly that the company is regaining its previous strength:—

	Net profit.		Amount carried to following year's accounts.
1891 ...	£21,988	...	£11,731
1892 ...	15,456	...	13,339
1893 ...	10,777	...	5,137
1894 ...	16,455	...	8,624

Birmingham Electric Supply Company, Limited.

The annual meeting of this company was held on Wednesday last week at the offices, Dale-end, Birmingham. The report recommended a dividend of 4 per cent., the placing of £1,602 15s. 3d. to the credit of the depreciation reserve fund, £250 to the general reserve fund, and the carrying forward of the balance of £1,001 11s. 9d. to the next year's account.

The Chairman (Mr. H. Buckley) in moving the adoption of the report, said there had been an increase of 20 per cent. in the output of current and of 28 per cent. in the number of consumers. Since they last met, the power they sought to enter Edgbaston and the jewellery quarter had been obtained. To deal with the extension of the mains it would be necessary to call up the unpaid capital of £2 on the 10,000 shares, and the directors advised that the capital should be increased from £100,000 to £200,000.

Mr. Arthur Keen seconded, and Mr. Edwards supported.

The Chairman said they did not mean to attempt to issue the 20,000 shares at once; they would issue them in blocks and offer them first to the existing shareholders. He could not pledge the board as to the terms at which those shares would be issued, but personally he would like to see them issued at a small premium, and that premium to be applied to wipe off the cost of the provisional order and the preliminary expenses.

The report having been adopted, the Chairman moved, "That the capital of the company be increased by £100,000, divided into 20,000 shares of £5 each (making the total capital £200,000), to be issued at such times and on such terms as the directors may from time to time think fit.

Mr. J. W. Lea seconded.

Mr. Keen was of opinion that the motion should be differently worded, so as to state that they would be issued at par and *pro rata* to the proprietors.

Mr. Myers (a shareholder) thought it was advisable to issue them at a small premium.

No amendment was moved, but the Chairman gave an undertaking that the new capital should not be dealt with until the board had had a meeting with the shareholders.

The motion was then carried unanimously.

A resolution in favour of obtaining a quotation on the Birmingham Stock Exchange was passed. The directors and auditors were re-elected.

Hove Electric Lighting Company.

An ordinary meeting of the company was held at the Cannon Street Hotel on Tuesday last, Col. H. Wood, vice-chairman, presiding. He said they could congratulate themselves on the satisfactory progress they had made during the past year. The lamps had increased by 10,000, which was evidence that the company was appreciated. They had already had to extend the mains, and the machinery would have to be supplemented during the present year. Sale of current had increased from £1,265 to £3,508, and as the major portion of the lights connected to the system were only coupled up late in the year, the receipts for the current year would be very much increased. The chairman then went through some of the figures given in the report, and spoke of the economy that had been effected in dispensing with a local secretary and office. He also dealt with the manner in which they proposed to divide the profit. It might be thought that the sum of £73 to be written off the suspense account was a small one, but they contemplated writing it off more quickly if the results of the working were satisfactory; but even if that rate of working were maintained, they would succeed in writing it off by the time the local authority were in a position to purchase the undertaking. If the business had been doubtful, they would have hesitated to pay a dividend, but seeing that the business consisted in supplying a commodity which had become almost a necessity, consequently the growth of revenue was almost assured. He expressed disappointment at the small amount of public lighting which had been adopted; the matter was, however, under the consideration of the Hove Commissioners, and he hoped that when they next met the shareholders, they would be able to announce that a contract for a large amount of public lighting had been made. He concluded by referring to explosions, and the immunity which they had had.

After some little discussion, the report and accounts were adopted.

Commercial Cable Company.

The statement of the company's business for the year 1894 shows that over 10 per cent. was earned on the stock. Seven per cent., or $700,000, was paid in dividends (the usual rate), and $310,439 was carried to the surplus account. Early in 1894 the last remaining $400,000 of debentures were cancelled, leaving the company entirely free of bonded debt, and placing the stockholders in possession of the property unencumbered and free from fixed charges of any kind. While the capital stock remains at $10,000,000, the value of the company's plant has been increased to $12,250,000 by the addition of the new main Atlantic cable, by the extension of the Canso-New-York cable from the landing place at Coney Island through the harbour to this city, a distance of 14 miles, and by the acquisition of wharf property and real estate at Halifax.

Planet Electrical Engineering Company, Limited.—From an official notice in the *London Gazette*, we learn that at a meeting held at 32, Victoria Street, S.W., on February 26th, a resolution was passed winding up the company voluntarily, as it could not by reason of its liabilities continue its business, and Mr. W. R. Caldwell Moore, F.C.A., of Palmerston Buildings, E.C., was appointed liquidator.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending March 10th, 1895, amounted to £971; week ending March 11th, 1894, £930; increase, £41; total receipts for half-year, 1895, £9,911; corresponding period, 1894, £9,474; increase, £437.

The Liverpool Overhead Railway Company. The traffic receipts of this railway for the week ending March 10th, 1895, amounted to £937; corresponding week last year, £687.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 8th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,689.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation March 6th.	Closing Quotation, March 13th.	Business done during week ended March 13th, 1895. Highest.	Lowest.
173,400*l*	African Direct Teleg., Ltd., 4 % Deb.	100	...	4 %	4 %	101 —104	101 —104	101⅝	...
1,012,880*l*	Anglo-American Teleg., Ltd.	Stock	£2 15s.	£2 11s.	£2 2s.	40 — 41	41 — 42	40½	...
2,993,560*l*	Do. do. 6 % Pref.	Stock	£5 10s.	£5 2s.	£4 4s.	75½ — 76½	78 — 79	77¾	76½
2,993,560*l*	Do. do. Defd.	Stock	...	...	...	6 — 6¼	6 — 6½	6⅝	6
130,000	Brazilian Submarine Teleg., Ltd.	10	6¾% §	6¾% §	...	11⅜ — 12¼	12¼ — 12¾	12⅝	11⅞
75,000*l*	Do. do. 5 %, repayable June 1906	100	5 %	5 %	...	109 —113	109 —113	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	10% ‖ §	... §	...	3 — 4	3 — 4	3½	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	148 —152	148 —152	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	2 % §	...	1/16 — 3/16	1/16 — 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	13 — 14	13 — 14	14	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20 — 21	20 — 21	...	...
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4 %	4 %	4 %	4 — 4½	4 — 4½	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	10 %	9½ — 10	9½ — 10	...	...
30,000*l*	Do. do. 4½ % Debs of £50, Nos. 1 to 1,600	...	...	...	4½%	103 —106%	103 —106%	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	2⅜% §	2 %	8½ — 9	8½ — 9	...	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	16½ — 16⅝	16½ — 16½	16½	16¼
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	17½ — 18	17½ — 18	17¾	17½
102,100*l*	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	105 —108	105 —108	..	...
1,297,837*l*	Do. 4 % Mort. Deb.	Stock	4 %	4 %	..	124 —127	124 —127	124½	124
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	...	17⅛ — 17⅜	17⅛ — 17⅜	17⅜	17
54,100*l*	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	...	103 —107	103 —107	...	...
194,300*l*	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	...	104 —107	104 —107	...	...
320,000*l*	Do. 4 % Deb. Stock	Stock	4 %	4 %	...	123 —126	123 —126	...	...
95,100*l*	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	...	103 —107	103 —107	104½	...
129,100*l*	Do. do. do. to bearer, 2,344 to 5,500	...	5 %	5 %	...	104 —107	104 —107	105½	...
300,000*l*	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	4 %	4 %	...	106 —109	106 —109	...	...
200,000*l*	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	...	112 —115%	112 —115%	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅞% §	4⅝% §	...	9¾ — 10	9⅞ — 10	10	9⅞
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	...	16⅝ — 16¾	16⅝ — 16¾	16¾	16⅛
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜% §	8⅜%	...	21¾ — 22¼	21¾ — 22¼	...	...
190,000*l*	Do. do. do. 5 % Debs.	100	5 %	5 %	...	104 —107	104 —107	105½	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	53 — 55	52 — 54	52¾	52
37,548	London Platino-Brazilian Teleg., Ltd.	10	2 %	2½%	...	5 — 7	5 — 7	...	...
100,000*l*	Do. do. 6 % Debs.	100	6 %	6 %	...	105 —109 xd	105 —109	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	... — ...	... — ...	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	6 %	6 %	...	1½ — 2½	1½ — 2½	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	5 % §	5 % §	5 %	5½ — 5½xd	5½ — 5½	5 7/16	5¼
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	...	15 — 16 xd	15 — 16	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	...	14½ — 15½xd	14½ — 15½	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	5 %	5 %	...	5⅜ — 6 xd	5⅝ — 5⅞	5 13/16	5 11/16
1,100,000*l*	Do. 3½ % Deb. Stock Red.	...	3½%	3½%	...	104 —106	104 — 106	105¾	101½
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	...	9/16 — 11/16	9/16 — 11/16	...	...
100,000*l*	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	105 —108	105 —108	...	...
11,839	Reuter's Ltd.	8	5 %	0 %	...	4 — 5	4 — 5	4½	...
3,381	Submarine Cables Trust	Cert.	...	...	...	119 —124	119 —124	123	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1 — 2	1 — 2	...	...
146,733*l*	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	85 — 90 xd	85 — 90	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	..	0 %	...	4 — 5	4 — 5	...	...
238,300*l*	Do. do. do. 5 % Debs.	100	5 %	5 %	...	101 —104 xd	101 —104	101¾	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	1½ — 2½	1½ — 2½	...	...
150,000*l*	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	98 —103	98 —103	...	...
64,245	Western and Brazilian Teleg., Ltd.	15	2½%	2½%	3½%	10½ — 10⅝	10 — 10½	10 9/16	10
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	5 %	5 %	5 %	6¼ — 6⅝	6¼ — 6⅝	...	...
33,129	Do. do. do. 5 % Def.	7½	...	...	...	4¼ — 4⅝	4 — 4½	4¼	...
171,900*l*	Do. do. do. 6 % Debs. "A," 1910 ...	100	6 %	6 %	6 %	101 —105	101 —105	...	...
214,800*l*	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	6 %	6 %	6 %	101 —105	101 —105	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅛%	3/8%	5/8%	⅞ — 1⅛	⅞ — 1⅛	1	..
34,563	Do. do. do. 6 % 1st Pref. ...	10	6 %	6 %	6 %	10⅜ — 11¼	10⅜ — 11¼	11¼	10⅜
4,669	Do. do. do. 6 % 2nd Pref. ...	10	6 %	6 %	6 %	9 — 10	9 — 10	...	...
80,000*l*	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	5 %	5 %	5 %	108 —111	108 —111	...	...
$1,211,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	115 —120	115 —120	...	...
166,900*l*	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	101 —103 xd	101 —103	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	5 %	4¼%	4½%	5 — 5⅛xd	5 — 5½	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	5 %	13 — 14 xd	13 — 14	13⅜	13 9/16
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	15 — 15½xd	15 — 15½	15 5/16	15 1/16
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	133 —136	133 —136	...	...
50,000	†Liverpool Electric Supply, all paid	5	5 %	5 %	5½%	7 5/16 — 7 7/16	7⅜ — 7⅞	7¾	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2 %	2½%	...	10¾ — 11¼	10½ — 11	11 1/16	10¾
100,000*l*	Do. 5% Deb., bonds of £10, £20, £40	...	5 %	5 %	...	... — ...	... — ...	...	...
150,000*l*	Do. 4½% first mortgage debenture stock	...	4½%	4½%	...	118 —120	118 —120	118½	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	1 %	7¼ — 7⅜xd	7¼ — 7¼	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	7½%	4½%	6½%	7½ — 8	7½ — 8	7⅞	7⅝
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8½ — 9	8½ — 9	...	...
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	3½%	4 %	5 %	7½ — 8 xd	7½ — 8	7⅞	7½

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation, March 6th.	Closing Quotation, March 13th.	Business done during week ended March 13th, 1895. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000...	3	6 % §§	6 % §§	...	2½ — 2⅝	2⅝ — 2⅝	2 11/16	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 % §§	6 % §§	...	2⅝ — 2⅝	2⅝ — 2⅝	2½	...
125,000£	Do. do. 4½ % Deb.	Stock	4½%	4½%	...	113 —116 xd	113 —116	114⅜	...
630,000£	City and South London Railway	Stock	⅝%	⅝%	1¼%	45 — 47	45 — 47	46	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	...	3 — 3½	3 — 3½	...	...
50,000£	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	5 %	5 %	...	102 —107	102 —107	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	*nil*	*nil*	...	¼ — ½	¼ — ½	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	...	1½ — 1⅝	1½ — 1⅝	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd., 1 to 66,750 ...	2	*nil*	*nil*	...	... — ...	... — ...	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	1⅝ — 1⅝	1½ — 1½	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	1⅛ — 1⅛	1¼ — 1½	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	...	½ — 1½	½ — 1½	...	...
9,600£	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	*nil*	...	6½ — 7½	6½ — 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	...	10 — 11	10 — 11	10⅜	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	10 %	23 — 24 xd	22½ — 23½	23¼	22¾
200,000£	Do. do. do. 4½ % Deb., 1896	100	4½%	4½%	4½%	102 —104	103 —106	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	1 %	1½%	8½ — 8⅝	8½ — 8⅝	8 17/32	...
6,295	† Do. do. Pref., £10 paid	10	...	5 %	5 %	13¼ — 13⅜	13½ — 14	...	...
	Swan United Electric Light, Ltd.	...	10 % §	7½% §	...	... — ...	... — ...	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	15 %	20 %	20 %	39 — 41 xd	39 — 41	40½	39½
150,000£	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £2 paid ...	10	...	...	...	2¼ — 2½	2⅜ — 2⅜	2 3/16	2⅜

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5⅜—6¼.

Electric Construction Corporation, 6 % Debentures, 84—87.

Electric and General Investment, shares of £5 (£1 paid), 1½—2

House-to-House Company (£5 paid), 3¾—4.

Do. do. 7 % Preference, of £5, 7¼—⅜

Do. do. 6 % Debentures of £100, 107—109.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 7¼—7⅜; 1st Preference Cumulative 6 %, £5 (fully paid), 7—7½.

Liverpool Electric Supply, £5 (fully paid), 7⅜—⅝.

London Electric Supply Corporation, £5 Ordinary, ⅜—½.

Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 98—100.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 5¼—5⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

Resumed Discussion of Mr. Sayers's Paper on "Reversible Armatures," &c. February 28th, 1895.

Dr. S. P. Thompson joined with the speakers of the previous evening of the discussion in congratulating Mr. Sayers on the progress he had made, and in congratulating the Institution that they were again the body before which Mr. Sayers had brought this communication as to his work. He took it that there was a main line of ideas running through Mr. Sayers's work which diverged in two directions. He wanted to get over the eternal difficulty of sparking at the brushes, and, having got over that difficulty, to rearrange his machine so as to employ the iron and copper to a greater specific advantage; that was to say, to gain from the manufacturers' point of view. He would first deal with the first of these lines of thought, the method of preventing sparking at the brushes, by which he was able to use the armature to magnetise the whole, or in part, its own field magnets. What were the ways suggested hitherto of preventing sparking? The original way, which they still used, was to give the brushes a forward lead, so that the reversal of the individual coils, or groups of coils, might take place just at the moment when they were entering a magnetic field of the right kind to balance the E.M.F., and to reverse the current and self-induction of that section. A number of auxiliary devices had been employed to enable sparkless reversal to take place, either putting the brush into that forward position, and he took it that the reason those other devices were sought for was because when you put forward the brush for the purpose of getting sparkless reversal you unfortunately produced at the same time a tendency to cross-magnetise and demagnetise and to prevent the machine from having the good regulating arrangement it otherwise should have. It had been proposed to employ an air-blast to blow out the spark; and it had been proposed, he thought by Mr. Mordey, to create somewhere or other in the neighbourhood of the commutator an auxiliary magnetic field, also to blow out the spark. Both these methods presumed that the spark was there to be blown out. Then there was the method of auxiliary poles which had been attempted by many inventors, Mr. Swinburne, and others. The papers read there two or three years ago by Mr. Esson and Mr. Swinburne both dealt with that method of using auxiliary poles. Then he thought Mr. Sayers had at an earlier period proposed a method very like that of auxiliary poles, by notching the pole-piece so as to produce a change of magnetic field in a certain place, and by that means obtain a sparkless reversal at some particular point, instead of having to put the brush forward to the tip of the forward pole-piece. And then there came the method that was known generally by the name of Professor Ryans, and which he believed was also independently suggested by Professor Forbes and which some others of them were working at the same time—it was a thing in the air—of cross-compounding, of winding a series coil over the armature, across it in fact, so as to compensate for the cross-magnetising effect. That method of cross-compounding by a series of conductors threaded in and out of the pole-pieces at right angles, so as to produce an auxiliary field at right angles, the ordinary magnetic field going through the armature, had been employed in America, but no European manufacturer had had resort to that cross-compounding method. It had two serious disadvantages; it complicated the construction somewhat, and it interfered to some extent with the ventilation and accessibility of the armature. Those being the older methods of fighting against the causes of sparking, there were the newer methods Mr. Sayers introduced two years ago and now in a perfected form with these regenerative armatures of his. The objection that was taken when he read his former paper, that his armature could only be used for revolving in one direction, he had now removed by the further development of bringing the commutator coils round at two places on the armature, and, if he understood the description aright, he employed that auxiliary pole piece which they saw indicated with the blue shading to cause his auxiliary coil, his compensating coil, to undergo an inductive effect after it had passed away from the ends of the pole piece proper, an effect which reversed in that auxiliary coil the E.M.F. which the auxiliary coil received a moment before when the binder side of it came out from under the pole-tip proper; that was to say, he was using the two edges of his compensating coil, the hinder edge first and then the forward edge afterwards as it passed underneath that auxiliary pole. Now he did not quite understand in what sense that armature was reversible. If he understood it rightly, the armature would work quite well if they were to take it out and put it into another machine which had the auxiliary pole-piece pointing the other way. In that case they would reverse the rotation from left hand to right, and it seemed to him, if it were truly reversible, they must not simply reverse its sensible rotation, but must reverse also the auxiliary poles. [Mr. Sayers: Certainly.] He noticed among other points that the armatures now proposed by Mr. Sayers differed from those he advocated two years ago in all, being of the drum construction. He (the speaker) had not tried it, but perhaps Mr. Sayers would tell them whether the method was equally applicable to ring-winding. With ring-winding where the individual coils were threaded in and out of the ring the adoption of this

reversible construction would either require that each commutator coil should consist of two ring-windings at a little distance from one another, or else two auxiliary drum-windings on the outside of the ring. Before passing away from this subject of prevention of sparking, he would like to know whether any member had had any experience of two other known ways of at any rate mitigating the difficulty about sparking at the commutator? Had anyone had experience about the use of oil? He did not mean putting a faint drop of oil on the commutator, but of running the commutator actually in oil, so that the spark might be crushed out of existence by the oil instead of being blown out or killed by a magnetic field. Secondly, had anyone had any experience of the method of killing out sparks which had recently been described by MM. Hutin and Leblanc in a machine they had invented for the purpose of commutating alternating currents into continuous currents? He was not very well informed as to the work which Hutin and Leblanc had done during the last year or two on this matter. They had published many short communications, describing a great many forms of machine, some of them alternate current motors, some alternate current transformers, to transform currents of one kind into polyphase or continuous currents, according to circumstances; but in one of their recent papers they had described a method of damping out the spark which would otherwise occur in the use of a revolving commutator to commutate alternating currents. This was so old a theme, that one would think that nothing new could be said about it; but he was inclined to think there was something new to be said. It clearly was most desirable that the electrical engineer, under present circumstances, where alternate current distributions were so widely employed, should have some practicable means of turning to account that portion of it which might be used for electrolytic or metallurgical purposes. Not until something of that kind was done would they be entirely satisfied to see electric supply entirely carried on by alternate currents, which had so many other advantages. The apparatus of Hutin and Leblanc was one which, by considering it on paper, looked very nice indeed, but he had had no experience, and wanted to know if anybody else had of this apparatus. He would very briefly describe it. They knew that when the armature was being used in the ordinary way, revolving between pole pieces, that a certain portion of the coils, namely, as much as was included in one section of the armature, would spark (?) as the current reversed in it while it passed, so to speak, under the brush; you reversed the current in the armature section by section. Now that operation occupied a little time, and during that time that section moved forward through a small angle, certainly not through its own breadth; in other words the reversal might take place much quicker than the time occupied for it to pass through its own breadth. A certain amount of current (?) was virtually transformed from one half of the coils to the other half of the coils, and the magnetising action of the coils in the end piece of this armature conspired to produce the resultant field which was shifted during the operation of reversal. The pole was *here* for a certain distance, and then a short time afterwards it was shifted on to the other end of the section, as if the magnetic field jumped back from one place to the other, during that time the armature was moved a little onwards, so that the actual magnetic jump due to the coil was not so wide as if they took the breadth itself. At any rate, the breadth was the same. At the commutation of every coil there was a small jump, a vibration backwards and forwards of the magnetic field of the armature. Hutin and Leblanc enclosed the entire armature in a stationary squirrel cage of copper. That was to say, they perforated the pole pieces just below their surface with a number of poles all round. He did not know how far this was carried out beyond, it might be carried through the whole space entirely round. A number of parallel copper bars were inserted; these were surrounded by copper bands in front and behind, and the armature lay in a squirrel cage. Now the tendency to shift the magnetic field backwards and forwards would certainly set up eddy currents in this squirrel cage. They would have currents going up one bar and down another, and these eddy currents would tend to oppose any change in the magnetic field; and the result, he was told, was—and it ought to be so on paper—that it maintained the magnetic field in a uniform position in spite of this commutation taking place, and therefore they might fix their brushes once for all and have no sparking. If all this was realised, in fact, he thought it was a most important thing. He would be very glad indeed if anyone could speak of that device. Returning to Mr. Sayers's paper, he would ask him why he mixed up together the terms slotted armature and tunnel armature. To his mind they meant quite different things. The slotted armature was nothing more than their old friend the toothed armature of Pacinotti, concerning which much had been said and written in former years. The tunnel armature he took to be the construction used years ago by Mr. Swinburne in the construction of machines with small air gaps, and in the Oerlikon Company's machines and those built by Mr. Brown. The distinction was so clear, as a matter of construction between having holes clean through the iron, and having slots between the teeth at the periphery of the iron, that he thought it was a pity to mix up the two things. The difficulty urged against the adoption of slotted armatures, namely, that insulation became more difficult, was one that had been got over in a number of different ways. Mr. Sayers did not say precisely how he got his good insulation with those slots; perhaps he would not mind telling them. He was very much struck in 1893 in looking at the machines, not only in the Chicago Exhibition, but in various factories up and down the United States, that so very small a proportion of the machines, whether continuous current, alternating current, or motors, had no smooth armatures. The smooth core armature, in fact, appeared to be an entirely obsolete construction in America. He thought of the hundreds, if not thousands, of armatures he looked at during his hurried visit to the States, certainly not 5 per cent. were anything but slotted armatures. He had regarded the smooth armature as an entirely bygone construction; but it was rather interesting to find a discussion being raised as to whether a smooth armature was not better than a slotted one. He wanted to ask Mr. Sayers another question. He remarked that he had not to alter the lead much on these machines when the load increased. When machines were made in that way with the regenerative armatures that enabled him to put the brush backwards instead of forward, what was to be done to the lead of the brushes as the load went on? Did he have to put them forward or backward? [Mr. Sayers: Backwards.] He supposed the thing would really depend upon the degree to which the commutation was put. Mr. Sayers increased the backward lead, he understood. [Mr. Sayers: As a rule.] Another point he would like to ask further information upon was this. In what did it occur that they wanted to run a machine backwards? Was there any case except train lighting, where the dynamo was run off the shaft of a carriage which had to go sometimes forward and sometimes backward? The complication hardly seemed worth while when they so seldom wanted a machine to run both ways. With respect to the formulæ Mr. Sayers had given them, he would remark that the machine constant seemed to have a physical meaning. What was it except something proportional to the torque of the machine? The square root of the torque would give the magnetic field at a constant speed, for if they drove at a constant speed the field would be proportional to the E.M.F., and the current would be proportional to the E.M.F., and therefore the product of the current E.M.F. of the output would be proportional to the square root of the field, so that the speed being constant they ought to have it as a matter of first principles that the field of the machine would be equal to the square root of the torque. He had hoped Mr. Sayers would say something about the use of his machines as continuous current transformers. They knew he had done something in that respect, using some of these short air-space compensating armatures for the special purpose of putting the E.M.F. that was wanted for distant transmission of the current, or, to use the expressive American term for such machines as "boosters." Might they know something more about those "boosters" and their performances? Mr. Sayers gave them some figures about the weight of a machine, the 80-kilowatt output machine. Certainly the figure obtained was fairly high. He was thinking of the matter rather from the point of view of the motor. They had a machine there which weighed about 67 lbs. for every horse power which it exerted if run as a motor. But in 1883, when Professor Ayrton read a paper about motors, in which he laid so much stress upon the weight of a machine, trying to have the lightest weight for a given power, the best figure he could arrive at was 90 lbs. gross weight per H.P. They had gone on a good deal since 1883 in various matters, but was not this rather a high figure? Was it not true that if you adopted one of the polyphase methods of transmitting power your motor, with 80 kilowatts, would not weigh more than 25 lbs. per horse-power output? There seemed to be some discrepancy there. He thought they ought to be able to make a continuous current machine which should have a less weight per horse-power than 67 lbs. In the abstract there was a way of looking at the use of copper and iron which ought to throw some light on the question of the construction for the minimum weight. The whole function of every dynamo was after all, to put it in a very abstract way, merely to produce variations in the coefficient of mutual induction between two coils, one of which happened to be fixed and the other movable, with an iron circuit in common. The coefficient of mutual induction between two copper coils, if they had equal weights, and were heated equally, the coefficient of mutual induction between two copper coils, if they were going to lose a fixed amount of energy in them and no more, would be a maximum if they divided it into equal parts, and put as many turns of such copper into one as they put into the other. If they wanted to get the best out of the copper, they would put equal weights of copper into the two windings. Was it advisable to go as far as Mr. Sayers, who was inclined to put all the copper on the armature and leave none on the field magnet? He thought it would be advisable not to carry the construction too far that way. He did not wish to express too strong an opinion on this matter, as it was an *a priori* way of looking at it. Hardly anybody in the world was at the present time working at the old commonplace problem of improving the continuous current dynamo; Mr. Sayers was the one man who had done anything in that way for the last two years, and they had to thank him for bringing his work there.

Dr. Du Riche Preller said the point to which he wished specially to refer in Mr. Sayers's paper was the considerable saving in weight, and he took it also in cost, which he claimed for his reversible and regenerative dynamos with slotted armatures. The type of direct current dynamo and motor with slotted armature that he was most familiar with was the C. E. L. Brown type, and it might not be uninteresting if he made a few comparisons between Mr. Sayers's machines and those of Mr. Brown. In the first place, he should like to point out that mere reduction in weight did not necessarily mean reduction in price, or in cost. Although of course it was very easy to reduce the weight of a motor or of a dynamo, it was not advisable to do so beyond certain limits, more especially if the machine was intended for normal work. By abnormal work he meant that of a motor for traction purposes, for instance. Even granting that Mr. Sayers reduced the weight, he did not think it showed any gain whatsoever over such machines as those of Mr. C. E. L. Brown. The weight of Mr. Sayers's 80-kilowatt machine, 100 H.P., worked out at 3½ tons; equal to 100 lbs. per kilowatt, but that was exclusive of foundation, frame and bearings. Now, Mr. Brown's 60-kilowatt or 80 H.P. motors only weighed 2·7 tons, complete, which was 90 lbs. per kilowatt. Again, Mr. Brown's 90-kilowatt, 125 H.P., motor weighed 3·3 tons, also 90 lbs. per kilowatt. These motors were four-pole steel-clad. Even the Thury dynamos and motors, which

were rather clumsy machines, as used by the Geneva Electrical Company, came out at about 110 lbs. per kilowatt complete. The ordinary type of Brown's 80-kilowatt direct current dynamo, that which corresponded exactly to Mr. Sayers's machine, was a four-pole generator and weighed 4·6 tons, or 127 lbs. per kilowatt, complete, and 3·5 tons, or 100 lbs. per kilowatt, exclusive of foundation, frame and bearings, the weight being thus the same as Mr. Sayers's. The speed of this dynamo was 420 revolutions at 110 volts. The 60 and 90-kilowatt motors ran at 450 to 550 revolutions. The weight of the 80-kilowatt dynamo of Brown's could, of course, be further reduced, but Mr. Brown refrained from so reducing it for ordinary work. All these machines had air spaces of 8 mm., or ⅓rd of an inch, which was much more than Mr. Sayers's, and he knew from experience that they ran absolutely without sparking. As regarded the question of short air space, he thought Mr. Parshall disposed of that. The next point he would like to mention was the efficiency. He believed Mr. Sayers gave the efficiency last time at 95 or 96 per cent.

Mr. Sayers: The efficiency of the dynamo, yes. It is given as 87 per cent. with the combined plant.

Dr. Du Riche Preller: That might be, but whether it would give that efficiency in actual work he was disposed to doubt. The motors and dynamos of C. E. L. Brown gave 93 per cent., inclusive, however, of frictional losses. The armature copper loss was about 2 per cent., and the shunt loss was also 2 per cent. He did not know whether it was fair to say anything about the price of these dynamos, but the Brown four-pole 80-kilowatt generator cost £330; he did not know whether Mr. Sayers could beat that. Perhaps he would mention something about it in his reply. On the whole he did not see much advantage in Mr. Sayers's machines. The very name, "reversible and regenerative," led them to expect something very phenomenal. He quite agreed with Mr. Mordey that it would be much better to call the machine the Sayers dynamo instead of regenerative. There was only one step from the sublime to the ridiculous, and he would drop the "regenerative" and call it the Sayers dynamo. Then there was the question of slots and tunnels. He was very much struck indeed when he saw the heading of the paragraph, "slotted or tunnel armatures." As Prof. Thompson had pointed out, the two things were so entirely distinct. A slot was an open groove, and tunnels were peripheral holes or perforations. The ordinary type of direct current dynamo and motor, such as he had described, certainly ran magnificently, and did every bit the amount of work that Mr. Sayers's regenerative machines were likely to do; and if Mr. Sayers had really reduced the weight of his machine, all he could say was that it must have been too heavy before.

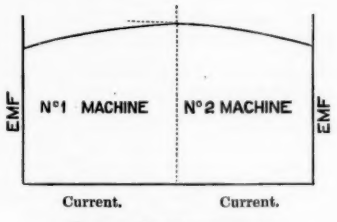
Mr. S. Evershed said he hoped he might be forgiven if he reminded the meeting that the subject under discussion was not the definition of the word tunnel and the definition of the word slot, but rather, given an armature which had what some people called slots, and other people called tunnels, how were they going to commutate it sparklessly? He thought it would be rather unfortunate if the discussion were left in the position in which Prof. Thompson left it, as though the question of commutating sparklessly were one simply of getting rid of the spark as though a spark were an unpleasant thing to look at. That was not the question at all. The real problem was how to move a coil from one circuit with its current in one direction, and place it in another circuit with its current in another direction, and to do that without damaging the commutator. They might bathe the commutator in oil if they liked, but they had to get rid of that energy and do it in the proper manner. The question of commutation was one fairly easy to understand. They had, as he had said, to take the coil out of one circuit and put it into another, and the first thing was to short-circuit the coil, which was not particularly difficult to do, because, as a matter of fact, armature coils had rather a tendency to short circuit. Having got it short-circuited, they had some induction threading it, and the first thing to do was to get it out, and the best way was to shove some in in the opposite direction. The moment they did that the current went to zero. Remember, they had not much time to do these things. Having shoved the right amount of induction in, and, of course, having got the current down to 0, it immediately began rising up in the other direction, and at a certain instant it was exactly to the right strength to be put into the other circuit. If they could happen to break the short circuit at that instant, then they got sparkless commutation. Now, where were they to get that induction from that they were to put into the coil, what he might call the negative induction, if the original was positive? There were two or three ways of getting that induction. The old way was to hunt for a place on the dynamo where there was some induction of the right sort that was on the pole, and the dynamo man hunted for it by shifting the induction coil until he found it. In 1887 Mr. Swinburne proposed—he (the speaker) did not know whether the thing was original with him—at all events, he went carefully into the question of reversing pole-pieces, and at Chelmsford he (the speaker) had the pleasure of seeing a great many drawings, which made it appear that Mr. Swinburne was going to patent every conceivable form of pole-piece. The only difference in the ways of commutating was in obtaining induction. Mr. Swinburne, for instance, would, by means of reversing, bring some induction to the coil, and reverse the coil and put it in. Mr. Sayers, for some reason or other, he was still somewhat at a loss to discover why, proposed to take his coil to the induction, and he did not want to have any back ampère-turns on his armature, as he would have if he shifted the brushes forward; he took the copper between the coil and the commutator sector to a place under the pole where there was an induction of the right value, namely, induction proportional to the current going into the machine. Now, that seemed to him, he confessed, a more complicated way of effecting the object in view, than putting a reversing pole-piece and putting the main current turns round the pole-piece, because, in the first place, although the weight of the machine might be reduced, it was perfectly clear that the labour of winding the armature was increased. He thought that went without saying. The chance of breakdown was also considerably increased. As he had had no opportunity of discussing this point when Mr. Sayers read his original paper on the question of commutator coils, it was, perhaps, hardly fair to discuss it now, when he had made over 100 machines and all of them had worked successfully, as he had no doubt they had, for it was an admirable way of reversing the coil, but, to his way of thinking, somewhat too complicated. But supposing this question of sparkless commutation had been got over in one of two ways, how were they to get the full benefit of the advantages? They could only get the full benefit when they could devise a notched armature which could be run with practically only mechanical clearance between the outside of the armature and the pole-piece, and as they saw from the diagrams, particularly diagram 5, they were still obliged to have large clearance in order to avoid eddy currents in the pole-pieces. The reason was simple. If they could wind the coils through holes in the armature—what some people called tunnels; he should think they might be called holes—if they wound the wires like that they had such an enormous induction round them, that the reversing pole-pieces or commutator coils had a great deal of work to do, and it was practically out of the question, he took it, in a large machine, to laminate the pole-piece, so that really the first thing designers had to do was to get over it; they must make the outside of the armature smooth by some means, and must make the best use they could of increased induction. Although he was not practically a dynamo builder, he had built probably more small air space machines than anyone in that room; he had built over 400, but as the output of the whole lot did not amount to 1,000 watts that did not go for much. Still, there was the fact that a serious drawback was the eddy current loss in the pole-pieces. Now, to come back to the reversing pole-piece, and also to the commutator coil, he had said that when they had the coil under the brush, that was to say, short-circuited, there was an instant when the current in it was of the right value to enable them to put the coil into the circuit, but in most machines it was only an instant, and that was also made a serious disadvantage in the commutation, because, unless all the coils were absolutely identical in the value of their coefficient of self-induction, the induction of one coil would not suit another, and the result was, that they never got rid entirely of sparking. The question was, could that be got over, and if so, how? He ventured to make a suggestion which might have nothing in it, but which he would give for what it was worth. What they really had to aim at was not only to make a negative E.M.F. in the coil by shoving negative induction into it, but after having reduced the current to zero and raised it to the right value again, they wanted to keep it there for a sensible time. If they imagined the current in the coil was flowing in that direction, at the instant of short circuit of course that current began to drop, and they could make it drop as fast as they pleased by putting in induction in the other direction at any rate they liked. It went down like this, and went up in the other direction so. Now, there was approximately the point where they had to put the coil back into the circuit, and it was perfectly obvious if the current was rising at anything like that rate, it was impossible to hit on the right spot for every coil in the armature and what they wanted to do was to get a curved line, so that the current, having reached its right value, remained there for a sensible time. When he said sensible, he meant compared with the whole time the coil was short-circuited, and it appeared to him it ought not really to be a problem imposible of solution to arrange the induction of the negative induction coil in such a fashion that it should be powerless to get the current beyond that value. They would then have any amount of space; there would be a sensible time during which they could put the coil into the circuit if put in the way corresponding to that straight spot, no matter if there were some small difference in co-efficient of self-iduction. How that was to be arrived at was not for him to say. It was a question to be gone carefully into. The man building the dynamo would have an opportunity of determining what to do by experiment. With reference to reversing pole pieces, one method of attaching them to a Manchester type dynamo had been shown by Mr. Ravenshaw on the wall, and as he (the speaker) prophesied for a certain reason that that machine could not commutate sparklessly, or at least that there must be some sparking, it was only fair to say that when he saw the machine running it was absolutely sparkless, so there must have been a flaw in his reasoning somewhere. A disadvantage was that the current turns they had to put on the pole-pieces were approximately equal to the cross ampère turns due to the current in the armature. That meant they had to put a reversing copper on the pole piece. Supposing they had an armature and they made a reversing pole-piece between the other two poles, which was a complete little magnetic circuit in itself, that was formed of E-shaped stampings. That type of reversing pole-piece ought to require very few ampère turns on it to produce the right field, for the simple reason that they had not got to fight against the cross ampère turns in the armature, and he could not help thinking that that was for more easy to deal with than the commutating device of Mr. Sayers. But, although that was his opinion, he must congratulate Mr. Sayers on being the only member of that institution, so far as he know, who had had the courage to deal with this problem. Reversing pole-pieces and sparkless commutation had been before them for ten or twelve years and no one had had the courage to tackle the subject before.

Dr. Preller wished to add a remark with reference to what Prof. Thompson had said with respect to the weight of alternating motors. He thought Prof. Thompson said the weight was about 25 lbs. per horse-power. He thought, with all deference, that that was too low. The lightest alternator that he knew—he was speaking of an 100 H.P. alternator—was 2·3 tons, which was 23 kilogrammes; that was 50 lbs., exactly double what Prof. Thompson had said.

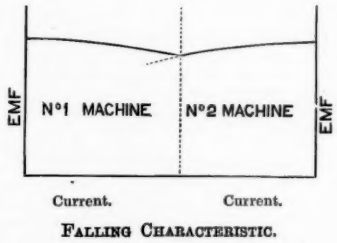
Prof. Thompson: I have not looked that up recently, and was speaking purely from memory.

The President said he thought there had been rather a tendency to undervalue Mr. Sayers's invention, not as an invention, but on the ground that a plain slotted armature was sufficient. That showed considerable want of knowledge on this subject on the part of those who made the remark. It was well known that the slotted armature had been gradually making its way from year to year, and that it presented great advantages in the way of making a good stiff, strong mechanical job, and in reducing the copper required on the field magnets. But it had also been contended that it had disadvantages in the way of producing difficulties at the commutator, and Mr. Sayers was really the first person who had tackled that difficulty, and that was the whole question. He (the president) also wished to join issue with Dr. Preller when he compared the efficiencies of Mr. Sayers's machines with the efficiencies of Mr. Brown's. No man had a higher respect for Mr. Brown than he, but Mr. Brown worked for a different market. Mr. Sayers had been working for the English market, which had a very high standard of efficiency; Mr. Sayers had been trying to produce a machine to compete with the machines of Siemens, the Electric Construction Company, and his (the president's) own firm, among others, well known to have an efficiency of 96 per cent., sometimes of 97 per cent., and producing it every time they were called upon to produce it. This was a state of things which was unknown on the Continent of Europe. He did not believe any Continental manufacturer was ever called upon to produce machines of such high efficiency, and there was practically no demand for them on the Continent. Doubtless, if Mr. Brown were called upon to produce them, he would produce heavier machines for the market. But things were different here. They had been educated up to the point of supplying these high efficiency machines, and they were necessarily, so long as they were smooth armatures, somewhat weighty. The continuous current machine, of which Prof. Thompson spoke rather slightingly, was certainly one of the most perfect pieces of mechanism ever seen, but it was costly, and it was with the view of reducing the cost, and without the disadvantage and trouble at the commutator, that Mr. Sayers had brought forward his invention.

Mr. Sayers said the first question with which he would deal was that raised by Mr. Andersen, who said one of the objections to the use of the slotted armatures was the heating of the pole-pieces. Now, there was no heating whatever of the pole-pieces, and no measurable loss of power from that cause if the proportions which he had already given were adopted. He had just used the word slotted, and would therefore deal with the point raised with reference to that. It had been asked why he called machines slotted and tunnel. The reason was that they merged one into the other. He started with a tunnel armature, a true tunnel or hole. That was why it was called a tunnel, because that was the shape. Then he found he had to slit it through. The moment that was done it was no longer a true tunnel. In various designs he made this opening wider or narrower, and the consequence was that he had slipped into calling them tunnel or slotted without knowing it. Mr. Andersen made some remarks about the arrangement for running the machines in parallel. He thought it was pretty clear in the paper that the arrangement suggested in fig. 8 was only for machines with a rising characteristic, and he did not think there could be many members who did not realise that. He might just say that, of course, the coupling of those continuous current machines in parallel did not depend in the slightest on whether they had compound coils or forward coils on them; it depended on the characteristic. He had made two diagrams which would make it clear. The first diagram was supposed to be the characteristic of two machines facing opposite directions. *This* was the E.M.F., and *this* the current. These machines were supposed to be coupled in parallel, and if the machines were giving equal current, then the division between the two machines would come about where he had put the dotted lines. Now, if the machines had a rising characteristic, it was quite easy to see that they could not possibly run like that, in parallel, because suppose No. 2 machine had a little more current than No. 1, the machines being identical, the consequence would be that its E.M.F. would be higher than that of No. 1, and it must give more current to the circuit, and the result of its giving more current to the circuit would be that it would rise still further, while No. 1 machine, generating less current, had a lower E.M.F., and so the thing would be unstable, and would go slap over immediately, and No. 2 machine would take all the current and send a back current through No. 1. But if the machines had a falling characteristic, the result of coupling in parallel was quite different, and the arrangement was quite stable. The lower diagram represented two machines with falling characteristics. If No. 2 machine gave too much current, its E.M.F. fell, and the current was taken off No. 1 machine in consequence, causing the E.M.F. to rise, so that the advantage was one in which stability would at once be attained; the division between the two would become equalised, instead of getting more unequal. Mr. Andersen was also the first to discuss the weight question. He gave the figure for a machine on the ordinary lines as 85 cwt., as against his (the speaker's) 92 cwt. Mr. Parshall stated that his machines had about the same weight, and Dr. Preller had just given them weights which were, some of them, a little less. Mr. Andersen did not, to the best of his knowledge, state whether the machines he was referring to were four-pole or two-pole. [Mr. Andersen: Two-pole.] Well, then, he gave the weight as 85½ cwt. as against his 62 cwt. [Mr. Andersen: I beg pardon; 64½ cwt. for yours, according to the paper.] He thought his was 62¾ cwt. However, he might say that the ratio he had found between his weights and those of other makers on the ordinary lines, comparing two-pole machines, was about 5 to 8, 5 for his machine against 8 for other peoples. Referring to Mr. Parshall's weights, and also to those given by Dr. Preller, the point to note was that both those machines were four-pole, but if he made his machines four-pole he made it half the weight. (No, No.) He thought it was a matter of general knowledge that a four-pole machine was approximately half the weight of a two-pole one for the same output and speed. It was considerably less at any rate. He could not say that he had worked it out or definitely designed a machine, but, according to Mr. Kapp's reasoning, it was so, and he had not been able to see anything wrong in that. He thought no one would dispute, at any rate, that the four-pole machines, output for output and speed for speed, were lighter machines than the two-pole ones. [Dr. Preller (handing photograph to the President), that machine disproves it.] Mr. Mordey called him over the coals for some other slips, chiefly with regard to various names he had given to commutator segments. He was very much surprised himself, on reading the paper over again,



Rising Characteristic.



Falling Characteristic.

to find that he had called commutator segments by four or five different names. That was a thing he had done quite unconsciously, and he would endeavour not to do it again. Then Mr. Mordey objected to the term, keepers. As he had mentioned in the paper, he was not the originator of the expression, and he did not think Mr. Mordey's criticism altogether just. They were not so rigid in their nomenclature as all that. The thing referred to might alternatively be called a yoke, but it had not the characteristics of a yoke like the piece on the top of a two-pole machine had. This thing, which was called a keeper by Lord Kelvin, was merely a piece of iron which completed the magnetic circuit, just in the same way that a piece of iron was put on to the old horse-shoe magnets to complete the circuit. He thought there was a similarity between the two things—a piece of inert iron which merely acted as a completion of the path. Then Mr. Mordey noticed and called attention to the fact that he made his armature reversible by doubling the commutator coil. Now, that was the case from a certain point of view. But from another point of view it was not at all the case. The doubling of the commutator coil, the making of it reversible, allowed of the use of the pole-piece, P, his form of polar projection. Now, the use of that pole-piece was to increase the effectiveness of a commutator coil; a commutator coil was not twice as effective with the pole-piece as it was without, for the reason that the leakage between armature and horizontal portion of the pole-piece was quite appreciable, so that the main coil which was subject to the reversing force was not working in anything like so neutral a field as it would be if that pole-piece were absent; consequently, the effect of that pole-piece was, not to double the effectiveness of the coils, but he thought it increased it by something like 75 per cent.

Mr. Mordey said, if Mr. Sayers would make it clear to some of us why he used a reversing pole-piece at all, it would be a great assistance. Seeing that he had the whole armature and could range over it where he liked, and could choose what E.M.F. he liked to get by his reversing coil, it seemed to him (the speaker) that the reversing pole-piece ought not to be a needed addition.

Mr. Sayers said he was just coming to a reason for using the reversing pole-piece. In the 80 kw. machine he had not taken full advantage of what he was going to describe, but there was undoubtedly in the use of that reversing pole-piece a means of very largely increasing yet further the output for a given weight of machine, for the simple reason that the amount of current that could be commutated was increased by its use by something like 75 per cent. In this particular machine, to say the least of it, he knew quite well that by simply increasing the weight of copper on the armature, and not making any other increase except the necessary increase in the depth of tooth and so on, by simply increasing the weight of copper he could increase the output of that machine to 120 kilowatts. The reason was—and this dealt with another point in the general criticism—that the increased load did not destroy his reversing field. He wanted to lay great emphasis on that. Several speakers had formed the impression that his main object and his main advantage had been to get a regenerative action from the armature with the view of keeping up the voltage, the compounding to keep a level characteristic. But the chief advantage of the thing was that you could not put enough current on to the armature to destroy the reversing

field. Although you might get up to the highest possible saturation, and then it was quite true you could not get any further, yet you had nothing like the conditions which you had in an ordinary machine, where, if your load exceeded a certain amount, you destroyed your reversing field completely, and had nothing to work with. Now, having got the reversing field indestructible, as it were, by the current in the external circuit, the output of a machine did not depend in any way upon the total induction or upon the mass of iron. He knew quite well, of course, that there would, for economic reasons, be certain proportions which would turn out to be best, but otherwise there was no limitation. The reason for that was this: The self-induction of the main section of an armature with holes or tunnels was, he took it, proportional to the length. He did not think there could be any question that the self-induction of the end connections was practically negligible. The self-induction, then, of the main conductors was proportional to the length; if you shortened the armature then you reduced the self-induction in proportion, but, if you shortened the armature and increased the diameter so as to keep N constant, while you lessened the self-induction, you did not lessen the reversing effect of the commutator coils, and the consequence was that, providing you went on shortening the armature and increasing the diameter, there was no limit whatever to the amount of current you could commutate with a given amount of field. It was from such considerations as these, and also far from the possibilities of what could be done with multipolar machines, that he made the statement that this machine, as regards weight and output for weight, was beginning where other types left off, and he was quite sure it could go down a long way with regard to weight. That was what he had to say chiefly on the question of design on that particular branch of the subject. This machine was the first of its type; it was a very safe machine, and it was not pared down in any way, and as he had said, its weight compared very favourably with the lightest that had been made on any other principle. It was beginning at the top of the scale, and it could go away down to something that had not been heard of. Mr. Mordey was wishing to introduce innovations in spite of his objections to his (the speaker's). He wanted to call this a correcting coil instead of a commutating coil. He thought the verb "to commutate" was sufficiently accurate; although he had always found "commutator coil" a cumbrous expression, he did not know how it could be improved upon. Mr. Ravenshaw had spoken of a machine of which he had very kindly made a diagram. His remarks were in the direction of showing that this was not the impossible construction which it was supposed to be, but he thought if Mr. Ravenshaw attempted to work out a machine of this size, he would find, although perhaps not impossible, it was impracticable. If he worked it out, he would find that he would require at least as much copper on the reversing pole-piece as he (Mr. Sayers) had on the whole machine, 6 cwt. or more, in order not to lose 1 per cent. round these pole-pieces. He thought the auxiliary pole suggested by Mr. Evershed a far more likely thing in the direction of reversing pole-pieces, but he thought even that would be found to be rather difficult to design, partly on account of the space occupied, and partly on account of its short circuiting the main field. It was a very difficult thing indeed to get that thing in without getting a terrible leakage loss. If they just conveyed the field round *there* they got a large surface *here* going up round like *that*, and it was quite evident they would get a terrible leakage loss *there*. He thought when anyone attempted to make a design, they would soon find they were in difficulties. He was exceedingly interested in the figures of Mr. Parshall's machines, in which the air gap was not greater than in some of his design or those of others, and Mr. Parshall's method of getting over the sparking difficulty was quite similar to the method adopted years ago in connection with smooth core machines, that was to say, he stiffened up the field. Mr. Parshall worked with an induction of about 20,000, in the projection of his armatures, and he got a considerable length of iron at that induction, and the result was that he got a very stiff field which was only slightly distorted by the armature current. He found it rather difficult to understand some of the statements that were made; for instance, Mr. Parshall assured him that there was no shifting of the brushes required in those machines. Now, it was perfectly certain, if the brushes were set in a position in which they would be sparkless at full load, that something or other must go on in the sections at light loads. He did not wish to call into question any statement, but he would remark that they all of them found a difficulty in distinguishing or in expressing degrees of sparking. A machine either sparked or it did not spark. Very little sparking was quite a different thing from sparklessness. He thought therefore that this statement that the various machines did not require any shifting of the brushes must be taken as meaning that they did not require that the brushes should be shifted in order to pass a certain standard which depended upon the personal equation of the observer; he thought it depended upon that a good deal as to what was called a non-sparking machine. Mr. Esson said that he had made machines up to 60 kilowatts 10 years ago which were non-sparking. He thought the remarks he had made about degrees of sparking applied to a case like that. Ten years ago they were hardly used to seeing a machine at all that was absolutely without a spark at the commutator. Whilst he was on this point about degrees of sparking, he might say a word in reply to Mr. Evershed. Mr. Evershed called attention to the fact that it was an exceedingly nice point to hit this curve exactly. He would first of all remark that it certainly required a minimum E.M.F. to create a spark of any dimensions. He did not know what that E.M.F. was, but it did not follow that because this line did not precisely coincide with the point of commutation, there would be sparking. He should say, roughly, that there could not be any possible spark with, say, a quarter of a volt. There must be a minimum which would give any spark at all. Consequently they had a certain margin in which there would be a slight variation, but not sufficient to produce a spark. If they did not get a spark he thought they would certainly not get any damage to the commutator, and then their machine would be absolutely sparkless and the commutator running perfectly. Then in connection with what Mr. Evershed said, he would point out that the curve for rise of current in the coil was in *this* form, and it depended entirely upon what part of that curve they stopped at whether there was any tendency to spark from that cause or not. If they got anywhere along *here*, of course, there would be no tendency to spark, and it would not matter whether the brush left connection at *that* point or *that* (indicating). But he must say in connection with that, that in practice he worked somewhere down *here* according to his calculations if the time constant was, say, *here*; if this was the time which the current would take to rise to ·63 of its maximum, this value of the current being $\frac{E}{R}$, and this being the time constant, he worked at something like a third of the time constant, so that he was working with a pretty steep slope. However, he thought the fact that a certain minimum E.M.F. was required to produce a spark was an explanation of the undoubted fact that these machines ran absolutely without any sparking whatever. He might say that with the alteration which he had made and which he had described in the paper, of extending this pole-piece, the position of the brush was not at all sensitive. He had a 32-kilowatt machine made with this extended pole-piece, and the brush could be shifted ·1 of an inch on the commutator without any sparking whatever, or any sign of sparking. A very rough adjustment indeed would fix it within those limits. Prof. Thompson asked if anyone had had experience of running a commutator in oil. He had not himself done so, but it was within his knowledge that the late Mr. J. E. H. Gordon used a commutator entirely immersed in paraffin oil in connection with the first large alternating machines which he made at the Telegraph Construction Company's works. An attempt was made to commutate the currents from those machines into continuous currents. He (the speaker) never saw it working, but Mr. Gordon had told him it was a complete failure. Prof. Thompson described a very ingenious arrangement by Messrs. Hutin and Leblanc, of surrounding an armature with copper in order to prevent a fluctuation of the field, and thereby do away with sparking. He had not done that exactly, but he had done a very similar thing; he had used a copper plate in the very same kind of way. In order to reduce the self-induction of an armature, he had placed a thick piece of copper just over the place where the current was being reversed, and he certainly found that effective, not to any very great extent, but it had an appreciable effect. He had also put his commutator coils in such a position in the slots or tunnels, that the field generated by the main conductor had to pass through those conductors, so that there were eddy currents generated in them, which tended to reduce the self-induction. He would conclude with the question of cost. He was not at liberty to give any figures; it was quite natural that he should not be. But he must say that he was surprised that this question of cost was looked at in the way it was. His experience, and the experience of others, was that these armatures were not more expensive to build than those of the ordinary type. In large machines they got rid of the necessity for laminating the conductor, and of the necessity for winding double or treble, or of going to four poles. They could make a two-pole machine such as that shown with only 36 sections in the armature, and working with a current of 800 ampères. He did not think anybody had done that before, and he did not think it had been accomplished except by duplex or triplex winding. This arrangement of his enabled that to be done, and they had a few part cheap commutator, and a few section cheap solid bar winding. He had not the slightest doubt those gentlemen who had called in question this matter of cost, and who had stated that one drawback was that the armature was more expensive, would find that it was quite the opposite; the armatures were cheaper, and not dearer.

THE ELECTROLYSIS OF GOLD. By N. S. KEITH, Member. Paper read March 14th, 1895.

Obtaining the contents of gold from auriferous rocks and ores by means of solvents and subsequent precipitation is now attracting much attention in both scientific and financial circles.

Because in some of the practised plans electricity takes an important part in the operations, I think some electrical information relating to the matter will be acceptable; therefore this paper.

In fully considering the subject, we would have to enter into the question of the possible formation of native gold in rocks and ores by electro-deposition from the solvent waters of the earth by action of earth currents. But as my paper is to deal more with practice than hypothesis, I shall leave that matter to the side, after stating a fact from which various deductions may be drawn. At the Dorn Gold Mine, in South Carolina, U.S.A., the rock formation is talcose slate. The soil is mainly the slate, disintegrated and decomposed. The slate is permeated by quartz veins of all sizes, carrying gold. The soil is also auriferous. Particles of gold in the soil are all rounded, as if they had been submitted to attrition or solvent action, while those in the rock are crystalline in form, bright, and with sharp, well defined edges. The gold from both positions is of equal quality, and the soil is of local origin. These facts seem to point to the present decrease of gold from the soil by solution, and increase, by deposition, of the gold in the rock.

Gold exists in natural auriferous materials in its native or metallic state, in irregularly shaped pieces, from scarcely above the size of an atom to that of, say, a hundredweight. The larger pieces give no special trouble in securing after they are found, and do not call for our consideration in this paper. The smaller particles—those of which it takes thousands, perhaps, to weigh a milligramme—are the minute things which engage our present attention, and the efforts of metallurgists and electro-chemists the world over.

The larger particles of gold are comparatively easily separated by

amalgamation from the powdered auriferous rock, owing to their weight causing them to sink into contact with mercury surfaces. But the lighter particles float in the water used, do not come into contact with mercury, and are lost to amalgamation. Many efforts have been made to use electricity in obtaining this finely divided gold. Most of them have been the dreams of unlearned enthusiasts, or the devices of dishonest men to obtain gold from the pockets of their dupes.

The "Rae process," which has received so much consideration at the hands of "experts" in recent patent litigation involving the "cyanide process" of McArthur-Forrest, was an effort to simultaneously dissolve gold from ores and deposit it on a cathode by electrolytic action. It failed for at least two reasons—(1) the imperfect knowledge of electro-chemistry of its inventor; and (2) from the impracticability of causing the particles of gold to remain long enough in contact with the anode to be acted on electrolytically. The dynamos used by Rae at the Douglas Mill, in Nevada, about eight years ago, in the effort to gain practical results, were series wound, and without polarity protectors. Carbon anodes (sometimes, by reversal, the cathodes) were used, suspended in amalgamating pans, in which the pulp was agitated. The sides and bottoms of the iron pans were to be the cathodes. At least half the time they were the anodes. The mercury in the pulp was to combine with the precipitated gold and silver.

By other inventors agitated mercury was made the cathode, and the fine gold was expected to mechanically "follow the current" into the mercury.

Whatever of value the electric current conferred was due to the fact that there was a reduction at the cathode of oxides and salts of metals, thus keeping the mercury with a clean, bright, unoxidised surface, so that it was in a more receptive condition.

The amounts of various metals dissolved or deposited by a coulomb of current have been accurately determined. For example, one coulomb sets free 0·000162 grain of hydrogen. We may express this quantity as one hydrogen-coulomb = 0·000162 grain. From this we gain the following values:—

One (dyad) copper coulomb $= \frac{0{\cdot}000162 \times 63{\cdot}5}{2} = 0{\cdot}0051035$ grain of copper.

One (monad) silver coulomb = 0·000162 × 108 = 0·017343 grain of silver.

One (triad) gold coulomb $= \frac{0{\cdot}000162 \times 196{\cdot}6}{3} = 0{\cdot}010611$ grain of gold.

One (dyad) mercury coulomb $= \frac{0{\cdot}000162 \times 200}{2} = 0{\cdot}016200$ grain of mercury.

One (dyad) iron coulomb $= \frac{0{\cdot}000162 \times 56}{2} = 0{\cdot}004536$ grain of iron.

One (dyad) lead coulomb $= \frac{0{\cdot}000162 \times 207}{2} = 0{\cdot}016767$ grain of lead.

One (dyad) zinc coulomb $= \frac{0{\cdot}000162 \times 65}{2} = 0{\cdot}005265$ grain of zinc.

For a practical, everyday-work unit, we may multiply each of the above quantities by 3,600 seconds in an hour to express the several quantities which an ampère will cause the solution and deposition of each hour. These quantities are as follows:—

Hydrogen-ampère-hour	...	...	0·5832	grain.
Copper	"	...	...	18·37	grains.
Silver	"	...	...	72·28	"
Gold	"	...	...	38·10	"
Mercury	"	...	...	58·32	"
Iron	"	...	...	16·30	"
Lead	"	...	...	60·36	"
Zinc	"	...	...	18·95	"

It has been found by experimenters in the line, and it may be accepted as a law, that the various elements bear a relation to each other, which relation we name "electro-positive" or "electro-negative," according to the method of expression. Some call it their "electro-chemical" relation. The electro-positive metals tend to composition with electro-negative elements. Thus, potassium is always electro-positive to the electro-negative oxygen. Elaborate lists of the electro-positive and the electro-negative elements are in the text-books. They have the order of arrangement which puts the most electro-positive first, followed, *seriatim*, by the less electro-positive, till at the lower end the most electro-negative element appears But one element may be electro-positive to another element in one solution, while in another solution the electro-chemical relation is exactly the reverse. For instance, in dilute sulphuric acid iron is electro-positive to gold; but in a solution of cyanide of potassium gold is electro-positive to iron. The electro-positive is always more soluble in the solution than is the electro-negative. If the electro-positive and the electro-negative metals be connected, electrically, while in the solution, the solving action of the liquid on the electro-positive metal is much increased—somewhat in proportion to the difference in their electro-chemical relation. Such a combination makes a galvanic battery, more or less approaching perfection. The placing of an extraneous source of electricity in such a circuit may increase the action, or even reverse it, depending on the direction of the electric current. The dynamic value of these actions may always be measured as watts by suitable instruments, such as an ammeter and a voltmeter.

The facts that gold could be dissolved by chlorine, aqua regia, bromine, cyanide of potassium, &c., have been known for many years. These facts have been put extensively into practical use for the obtaining of gold from ores by means of chlorine gas, in the Plattner process, and its modifications. From the solutions so obtained the gold is deposited by ferrous sulphate ($FeSO_4$). For one reason or another, not necessary to consider here, electrolytic precipitation of the gold from this solution of auric chloride ($AuCl_3$) has not been practised in the art. Electro-gilding, using gold anodes, and various metallic objects as cathodes in an electrolyte consisting of auro-cyanide of potassium (K Cy Au Cy) in a solution of potassic cyanide (K Cy) has been practised for about 50 years. Its details are too well known to need consideration here.

(To be continued.)

NOTE ON THE SPECTRUM OF ARGON.*

By H. F. NEWALL.
Communicated by Lord Rayleigh.

In the course of a spectroscopic investigation in which I have been for some time past engaged, a line spectrum, which, so far as I was able to make out, was unknown, has frequently presented itself upon my photographs. It appeared in May and June, 1894, under conditions which led me to call it, for the sake of convenience, "the low-pressure spectrum." After their announcement at the Oxford meeting of the British Association, it seemed, for many reasons, natural to borrow the first letter of Lord Rayleigh's and Prof. Ramsay's names to give to the unknown lines, and in the measurements of the photographs which showed the lines well, there appears an "R" against 17 lines out of 61 measured, the remaining lines being known to belong to Hg, H, N, and nitrocarbons. It transpires now, as I learnt from reading the abstract of the paper in which Lord Rayleigh and Prof. Ramsay describe their consummate researches on argon, that the symbol "A" should have been used instead of "R" to designate the lines on my photographs. For the lines are argon lines.

The conditions under which the spectrum of argon has appeared in my investigations are of interest at the present time, and I hope a description of them may not be unacceptable.

A glass bulb was sealed hermetically to a mercury pump of the Hagen-Töpler form, in which there was strong sulphuric acid floating on the surface of the mercury. The bulb was exhausted as low as possible and refilled with air. The pressure was reduced to about 180 **M**illionths of an atmosphere (= 0·14 mm.), at which pressure a bright discharge could be passed through the residual gases by means of Prof. J. J. Thomson's method of surrounding the bulb by a coil of wire, which carries a very rapidly alternating current produced by the discharge of a condenser.

The discharge was passed for 30 minutes, during which time a photograph of the spectrum was taken. The pressure of the gas in the bulb fell during the passage of the discharge from the value 174 **M** (= 0·13 mm.) to 112 **M** (= 0·085 mm.). The spectrum shows the bands of nitrogen strong, also mercury lines and nitrocarbon groups strong, hydrogen weak, no oxygen or argon.

Again the discharge was passed for 30 minutes and a new photograph was taken. The pressure fell from 100 **M** (= 0·076 mm.) to 20 **M** (= 0·015 mm.); the nitrogen spectrum had faded considerably, and there had appeared a number of fine lines which I was unable, in spite of careful efforts to identify with the lines of any known substances.

The nature of my method of investigation of spectra is such that it is not difficult to pick out of the numerous spectra which appear superposed on the photographic plate, the lines which belong to any one spectrum.

The results of measurement made in the last few days of 72 lines in my "low-pressure spectrum" are given, and side by side are given the measurements of the wave-lengths determined by Mr. Crookes for the argon lines.

The agreement of the measurements shows conclusively that we have been measuring the same spectrum. Between H_γ and wave-length 370, the agreement is all that we could hope for, taking into account the fact that my measurements were not made with a view of giving a final and carefully-considered set of measurements of wave-lengths, but between H_γ and H_β there is a systematic difference of about three tenth-metres, which I am unable at present to account for. The agreement of grouping and intensity, however, leaves no doubt as to the identity of the spectrum of my low-pressure lines with the spectrum of argon. I have reduced my measurements with reference to Rowland's scale of wave-lengths, and I infer from the value adopted for the H_β (F) line, that Ångström's scale has been used in Mr. Crookes's reduction. The difference between the scales is not enough to account for the discrepancies above referred to.

The experiments were repeated, with slight variations, several times with results which, so far as the spectrum of argon is concerned, were constant. But it was noted that continued passage of the discharge appears to result in the attaining of a certain minimum pressure, after which there is slight and slow rise to a tolerably fixed pressure. It is not necessary to dwell on these points in the present note.

It is interesting to find argon asserting itself, unsolicited, in quite new circumstances, and under conditions which practically constitute one more mode of separating argon from nitrogen—namely, the getting rid of nitrogen by passing electric discharge through it in the presence of hydrogen, or moisture and acid.

* Royal Society. Received February 14th, 1895.

TABLE OF WAVE LENGTHS.

H. F. Newall.		William Crookes. January 24th, 1895. The two spectra of argon.			
Measurements of lines on photograph.		Blue.		Red.	
Wave length.	Intensity.	Wave length.	Intensity.	Wave length.	Intensity.
4879·8	5	487 9	10	487·9	4
4847·2	5	484·75	1		
4808·0	9	480·50	7		
4766·6	5	476 30	1		
4738·0	8	473 45	6		
4729·4	6	472·66	2		
				470·12	8
4659·6	7	465·65	5		
4644 0	1				
4639 0	2				
4632·1	4			462 95	5
4611·0	9	460 80	8		
4592·0	8			459 45	2
		458 69	6		
4581·2	6	457 9	6		
4546·5	7	454 35	7		
				451·40	2
		450 95	8	450 95	9
4482·2	6	447 83	6		
4460·0	2				
4431·3	10	442 65	10		
4426 0	10	442·25	10		
4421·2	4				
4414·1	4				
4401·7	9	439 95	10		
4400·1	5				
4379·8	8	437 65	9		
4375·8	3				
4370·4	8	436·90	9		
4351·4	7	434·85	10		
4336 0	2			434·50	5
4330 8	10	433·35	9	433·35	9
4308·7	4			430·05	9
4299 4	4	429·90	9		
4282·1	6				
4277·4	8 ? N	427 70	3		
		427·20	7	427·20	8
4266·4	9 ? N	426·60	6	426·60	4
		425·95	8	425 95	9
		425·15	2	425·15	3
4227·5	8	422 85	6		
		420·10	10	420 10	10
CN group has, though only of intensity 5, obliterated this set of lines.		419 80	9	419 80	9
		419 15	9	419 15	9
		418·30	8	418 30	8
		415·45	8	416·45	4
		415·95	10	415·95	10
4155·8				415·65	6
4130 9	6	413·15	3		
4104·2	8	410·50	8		
4082·2	4				
4075·8	3				
4072·4	9	407 25	8		
4069 7	2				
4042·7	5	404·40	8	404·40	9
4038·2	5				
4035 0	2				
4033·7	3	403 30	1		
4013·8	8	401·30	8		
3994 8	6				
3991·3	4				
3979·2	3	397 85	1		
3973·0	4				
3968·0	7	396·78	3		
		394·85	9	394·85	10
3944·1	5	394 35	3		
3932·3	5				
3930·8	3	393·18	3		
3928·2	8	392·85	9		
3920·3	6				
		392·75	3		
3918·8	5				
		391·50	1		
3892·2 ?	—			390·45	8
3883·2	5	389·20	5		
3873·4	4	387·55	2		
		387·18	2		
3868·1	6	386·85	8		
3850·8	7	385 15	10		
		384 55	1		
		383·55	2	383 55	3
3827 0	—	382·75	2		
3809·8	4	380 95	4		
		380·35	1		
		379 95	1		
3781·8	6	378·08	9	377·15	1
		377 05	2		
3766·1	5	376·60	8		
3750·2	3				
3738·8	3	373·85	3		
3730·0	8	372·98	10		
3719·2	2	371·80	4		

ELASTIC COUPLINGS.

WRITING to our contemporary, *L' Industrie Electrique*, M. V. Bablon deprecates the abnormal use of mathematics in dealing with the question of elastic couplings between gas engines and dynamos. Hitherto, he writes, the subject has been simply a theme on which to expend brilliant algebraic variations, and he asks for less of fugues in X major, and a little more simple melody. Without so many figures it is evident that a convenient elastic intermediary placed between a motor and a dynamo cannot but serve to lessen the shocks between the two, and M. Bablon would reproduce the substance of what he wrote in a letter to M. Fontaine in September last. For four years he has employed a little dynamo of 250 watts, driven by a gas engine of 25 to 30 kgm. per second, and furnished with an elastic coupling that has given him satisfaction. This consists simply of a spring of a clock or of a turn-spit placed in the pulley of the dynamo, transformed for the purpose into a barrel turning free on the spindle, the spring being fixed to the spindle by a bolt and also to the barrel by another bolt, the belt running on the outer rim of the barrel as a pulley. The motor runs at 300 per minute, with an explosion every revolution. It has two equal fly-wheels, but in spite of favourable conditions, the oscillations of speed were very marked without the elastic coupling, but with it were almost extinguished, and would have been, perhaps, quite extinguished had a more elastic spring been used, one, for instance, of greater length. The Raffard elastic coupling on which M. Picou based his calculations, in a recent article in *L' Industrie Electrique*, seems to the author to have been entirely planned to couple two spindles very nearly but not quite in line, and it will serve to decrease the shocks between motor and dynamo if the angular movements to be taken up are limited to a not too great a fraction.

An ideal spring to interpose between a motor and a machine so as to prevent transmission of shocks, would be one the tension of which would not vary in spite of all possible changes of length, torsion, or wrapping. Such a spring does not exist, but one is able to go as far as one wishes in increasing more and more the length of the spring, so that the displacements between the two points of attachment of the spring change less and less the initial tension.

Having a 2 horse Otto engine running at 180 revolutions, it was first desirable to learn what was the amplitude of the angular displacement of the fly-wheel relative to the normal position it should occupy if speed were invariable. The fly-wheel was illuminated by means of a Geissler tube, excited by a Ruhmkorff coil, regulated so that its flashes coincided with the frequency of the passage of the fly-wheel arms through a given position. So long as the fly-wheel velocity was constant, the arms were visible at this instantaneous position by the light of the flashes, and the wheel appeared to be stationary, but as the velocity varied and the wheel ran slower, it appeared to have a slow retrograde movement, for the arms did not reach the given position at the moment of flash. Then, a fresh explosion taking place, the wheel would appear to slowly reverse its movement and overrun the flash point. In fact, the wheel appeared to swing slowly between two extreme positions, and its angular movement was easily measurable, the eye grasping readily the progress of the alternate advances and retrogressions.

In light running, with one explosion every four or five cycles, the maximum angular movement was 50°. With load on, and only one explosion missed out of four or five possible, the angularity was 8° for successive explosion cycles, and attained barely 12° after a non-explosive cycle followed by explosion.

There are two places in which a spring can be placed—the shaft of the motor or the spindle of the dynamo. For the first the angular movement of 15 degrees, as above, need alone be provided for, but for the second place, the speed being ten times as fast, the angular movement will be ten times as great for deadening shock, or 150 degrees, and the spring would be very long but correspondingly easy in working, and so far the author has worked on these lines, but on the whole he thinks it better to use a shorter and stiffer spring and place it on the motor between the fly-wheel and another fly-wheel pulley which drives the dynamo, but is loose on the motor shaft except so far as the spring transmits the movement. The use of a band of India-rubber is considered as suitable for the 2 H.P. motor.

If attached at the extremity for a radius of 0·7 m., then a displacement of 15 degrees represents a length of 0·18 m. approximately, and for 2 H.P. at 180 revolutions the pull at the above radius will be 11·36 kilos. It comes then to a question of using a band capable of standing a pull two or three times this amount. It is a question of section, the band being already normally stretched by a pull of 11·56 kilos, and the displacement of 15 degrees being supposed not to cause a pull of more than a tenth in excess of the normal. Thus a stretch of 0·18 must be obtained by an excess of pull not more than $\frac{11\cdot36}{10}$ kilos. This is to be used in fixing the length of the band, and there only remains, if not already known, to determine the elongation and strength of a band of India-rubber, from which can be deduced the dimensions of the desired spring, and it is certain that such a spring conveniently placed—an arrangement the author is now busy with—will reduce the variation between driver and driven to a tenth of its normal amount.

It by no means follows, however, that the variation would be even a tenth of present values, for before the driven shaft could follow in the time the elastic coupling would have begun to return to its normal position or extension. Especially would this be so if a second fly-wheel were applied on the driven spindle.

To sum up—without some interpolated elasticity the strokes of the motor are transmitted rigidly to the driven shaft, or, as the French well term it, the "mobile," except for the slipping of the belt. With too short a spring, as in the case considered by M. Picou (in a previous number), the action is faulty, partaking of the character of hunting, the driver and driven shafts overrunning, and the spring shortening and lengthening beyond proper amount.

Theoretically and practically it is possible to reduce shocks and irregular driving to just such a degree as we wish, and M. Bablot hopes to secure the end he is aiming at in elastic couplings, and should he do so promises to publish his results.

NEW PATENTS—1895.

4,019. "An improvement in electric apparatus for engine-room signalling and like purposes." S. M. Eardley-Wilmot, W. T. W. Thackeray, S. Hoare, and K. R. Mackenzie Dated February 25th. (*Complete.*)

4,038. "Improvements in or relating to telegraphic apparatus, applicable for use in ships or other purposes." J. B Irvine and G. Foulkes. Dated February 25th.

4,065. "Improvements in electric tramways and apparatus connected therewith." S. Z. de Ferranti. Dated February 26th.

4,085. "A device for switching off the current from an incandescent electric lamp by a movement of the lamp itself, without its removal from the holder." W. W. Martin. Dated February 26th.

4,106. "Dynamo-electric generators and motors." A. E. Lones. Dated February 26th. (*Complete.*)

4,111. "Improvements in electric insulators." G. F. Chuiter. Dated February 26th.

4,119. "Improvements in electric contact strips." C. Meray-Horvath. Dated February 26th. (*Complete.*)

4,120. "Electric heaters for applying artificial heat to the human body and also for the purpose of artificially heating apartments, cars, furniture and such like." J. E. Meek. Dated February 26th. (*Complete.*)

4,153. "Method of and apparatus for insulating electrical conductors." J. Y. Johnson. (Communicated by L. W. Downes, United States.) Dated February 26th. (*Complete.*)

4,154. "Improvements in apparatus for use in electro-deposition." The Cowper-Coles Galvanising Syndicate, Limited, and S. O. Cowper-Coles. Dated February 26th.

4,160. "Improvements in electric transformers or converters." H. H. Lake. (Communicated by the Thomson Electric Welding Company, United States.) Dated February 26th. (*Comp'ete.*)

4,182. "Improvements in electrical furnaces and in regulating and working the same." D. Urquhart and F. Wynne. Dated February 27th.

4,215. "Improvements in electricity meters." H. Herbeets. Dated February 27th.

4,245. "Improvements in electrical galvanic batteries." G. Laura. Dated February 27th. (*Complete.*)

4,255. "A rheotone or novel apparatus whereby a battery of great internal resistance is rendered capable of generating an induction current in coils of low internal resistance." G. Laura. Dated February 27th. (*Complete.*)

4257. "Improvements in or connected with electric arc lamps." W. P. Thompson. (Communicated by W. A. R. Mathiesen, Germany.) Dated February 27th. (*Complete.*)

4,260. "Improvements in electric apparatus for indicating or recording at a distance the position or motion of a primary mechanism." A. Custodis. Dated February 27th. (*Complete.*)

4,303. "Electric signalling arrangement for locks and the like." H. Nohmer. Dated February 28th.

4,323. "Improvements in cases for accumulator batteries." W. C. Johnson. Dated February 28th.

4,330. "Improvements in electric arc lamps." J. Y. Johnson. (Communicated by Suddeutscher Rödrendampfkesselbau Simonis and Lang, Germany.) Dated February 28th.

4,352. "Improvements in dynamo-electric machines and motors." L. B. Atkinson. Dated February 28th.

4,357. "An improved electrical apparatus for reproducing images of distant objects." R. Berglund. Dated February 28th. (*Complete.*)

4,426. "Improvements in incandescent electric lamps." J. Wende. Dated March 1st.

4,458. "Improvements in or relating to apparatus for electrically steering ships." F. A. Langen. Dated March 2nd. (*Complete.*)

4,466. "An improved arrangement of lenses for search-light projectors." E. J. Paterson and C. W. Hill. Dated March 2nd.

4,490. "Improvements in dynamo-electrical machines." S. Z. de Ferranti. Dated March 2nd.

4,497. "Automatic current permutating device for electro-magnets." O. von Morstein. Dated March 2nd. (*Complete.*)

4,499. "Improvements in or relating to electric indicating apparatus." R. Myers. Dated March 2nd.

4,525. "Improvements in electrically operated stringed musical instruments." H. H. Lake. (Communicated by W. S. Reed, United States.) Dated March 2nd.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1894.

4,849. "Improvements in casings, culverts, or means for supporting and protecting electrical conductors." G. St. John Day and S. Allmark. Dated March 8th. The inventors form the casing of wood, or other suitable substance, which has a groove or grooves provided in two opposite sides thereof, instead of underneath the length of the material as at present in use; thus leaving a central solid portion between the grooves for keeping the remainder of the piece intact. 1 claim.

7,145. "Improvements in or connected with the electro-deposition of zinc or zinc compounds, and the treatment of the deposited metal or compounds." S. O. Cowper-Coles and B. W. Walker. Dated April 10th. Consists in the employment of an alkaline electrolyte, to which is added, in a state of fine division, the zinc, or zinc compound to be deposited, or to form part of the deposit. 4 claims.

9,974. "Improvements in or relating to apparatus for heating metals electrically." W. P. Thompson. (A communication by C. L. Coffin, of Detroit.) Dated May 22nd. The material being placed in position and connected with the generator, electrodes are brought in contact with the material, thus establishing a circuit through a conductor, a rod, another conductor, a brush, a contact plate, one electrode, the material, and a conductor. When the electrode becomes hot, the brush is shifted to the contact plate of the next electrode, and when this second electrode becomes hot, the brush is shifted to the next electrode. As the electrodes heat very readily, and retain their heat a considerable time, quite a number of them can be heated, and then, by shifting the brush more rapidly, they are all maintained at a high heat, and heat the material by incandescence. 6 claims.

10,044. "An improved system of producing luminous electric changeable writing, and in apparatus therefor." The Marquis Alfonso Theodoli. Dated May 23rd. Consists in arranging in rows or any other suitable way, a certain number of frames, preferably all made alike. Upon each one of the said frames are fixed some incandescent electric lamps, arranged in such a manner that by lighting some of them and leaving others not lighted, it should be possible to delineate with them by means of luminous points, either a letter, a number, or any other sign. 6 claims.

13,794. "Improvements in electric conduits and conductors therefor." J. W. Eisenhuth, R. Herman and E. M. Herman. Dated July 17th. Relates to improvements in underground systems for electric railways, and the objects of the invention are, first, to provide a conduit in which the loss of the current from leakage will be reduced to the minimum; second, to so form said conduit, that all dirt water, &c., falling into the same will be carried off therefrom; third, to provide a conduit in which the positive and negative wires or conductors may be very near together, without any danger of short-circuiting between them; fourth, to provide an improved trolley wire or conductor, wherein the greater part of the current shall be carried in an insulated conductor, and only a small portion of the current, that required for immediate use, shall be exposed. 21 claims.

13,803. "Improvements in magnetic locks, or apparatus for opening the locks of safety lamps by magnets only." C. E. Stallybrass. Dated July 19th. Relates to an improved method of applying magnetism to the unlocking of spring locks attached to safety lamps, whereby the lamps when once locked or fastened, which is done automatically by a spring or springs, can be unlocked or opened only by the application to and contact with the lock of a powerful magnet, either static or dynamic. 3 claims.

14,607. "Improvements in electric cable traction apparatus." R. Lamb. Dated July 30th. Consists of a main cable supported upon suitable brackets extending along the route of the proposed cable way, and connected with one pole of a dynamo. Upon the cable is suspended a two-wheeled car or trolley, from which hangs an arm provided at its lower end with the operator's seat. In a journal box attached to the pendent arm is journalled a shaft, carrying at one end a worm wheel shaft, and at the opposite end a grooved sheave, the said grooved sheave receiving upon it one or two convolutions of a traction cable, also supported by the bracket, and connected with the remaining pole of the dynamo. The traction cable is also grounded at the end farthest from the dynamo, and the same pole of the dynamo is preferably grounded. The pendent arm carries an electric motor, the armature shaft of which is provided with a screw engaging the worm wheel on the shaft of the grooved sheave. Current is taken for the propulsion of the electric locomotive from the main cable, and is returned to the dynamo by the traction cable. 9 claims.

14,642. "Electrical battery." V. I. Feeny. (Communicated from abroad by F. Dubero and P. Mohrdieck, both of San Francisco.) Dated July 31st. The object of the invention is to provide a continuous or constant battery, the elements of which are renewed during the operation of the battery, and in the employment in conjunction with said battery of sea water as the active energising element. 4 claims.

15,276. "Improvements in or connected with diaphragms for electrolytic purposes." M. Kiliani, W. Rathenau, C. Suter, and the Corporation, "Elektrochemische Werke," Berlin. Dated August 10th. According to this invention, the diaphragm material is enclosed within two frames combined therewith, in a peculiar manner, which, in addition to rendering the whole arrangement extremely simple and easily controllable, has the advantage of facilitating the firm and reliable locking or securing in position of the walls of the diaphragm. 4 claims.

15,321. "Improvements in and relating to flexible telephone cords." O. Schrimpff and R. Riffelmacher. Dated August 11th. A flexible cord constructed according to this invention is provided with the usual two insulated conductors, and with an additional or third cord, by means of which the cords and the telephone are suspended. This third cord is furnished with a loop hook or other device for the purpose of suspension. The ends of the conducting cords are furnished with contact pieces, by means of which they are easily attached and detached. 3 claims.